Q. Please provide all studies showing the emissions which will result from the operation of this CTG and provide a comparison to the existing emissions from the installed units at Holyrood.

A. Please find attached as GT-DD-NLH-041 Attachment 1, the air emissions modelling report, *CALPUFF Air Dispersion Modelling for the Holyrood Combustion Turbine Project*, SNC-Lavalin, 2014. Table 11 on page 20 in the attached report provides a comparison of existing emissions for Holyrood Thermal Generating Station as a singular point source and the combustion turbine as a singular point source.

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FINAL REPORT

Calpuff Air Dispersion Modelling for the Holyrood Combustion Turbine Project

Newfoundland and Labrador Hydro

ENVIRONMENT & WATER

2014 | 05 | 15

REPORT > ORIGINAL
Internal ref. 617627-ENVI-4EER-0001_01

CALPUFF Air Dispersion Modelling for the Holyrood Combustion Turbine Project

Final Report

Newfoundland & Labrador Hydro

May 2014

Project: 617627

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To demonstrate our commitment to the importance of quality, our priority to meet the requirements of its clients and our commitment to continuous improvement, the Environment & Water business unit has developed a Quality Policy and a Quality Management System tailored to our activities. Hence, we recognize that the quality of our services is based upon:

- Safely executing our work;
- Collecting precise and complete information (inventories, surveys, research);
- Providing deliverables that are technically sound, clear and concise;
- Meeting deadlines;
- Delivering projects on budget;
- Providing invoices that are timely, clear and accurate;
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SUMMARY

In order to meet peak electricity demand in the Province, Newfoundland & Labrador Hydro (HYDRO) is considering the installation of additional generating capacity by means of a 123 MW (nominal) light oil fired combustion turbine (CT) peak-shaving production unit on the site of the existing Holyrood Thermal Generation Station (HTGS).

The CALMET/CALPUFF air dispersion modelling system was used to estimate ground level concentrations of several contaminants resulting from the operation of the CT unit and the adjacent HTGS station. The modelling scenarios were defined by HYDRO and in consultation with the DOEC. Hourly production profiles for years 2003 and 2004, corresponding to the highest production rates of the HTGS during the last ten years, were considered with continuous production from the combustion turbine unit from November to April inclusively. The unit chosen for this exercise has a nominal 123 MW ISO rating.

Modelling results show that the current HTGS will remain in compliance with the provincial ambient air quality standards (AAQS) defined in the *Air Pollution Control Regulation, 2004* for the combined operation of the HTGS with the CT unit for all contaminants considered in this study:

- Sulphur Dioxide (SO_2);
- Nitrogen Dioxide (NO_2);
- Carbon Monoxide (CO);
- Total Particulate Matter (PM_t);
- Fines Particulates < 10 µm (PM_{10});
- Fines Particulates < 2.5 µm ($PM_{2.5}$);

For most contaminants, the addition of the CT unit would not significantly increase the maximum ground level concentrations in ambient air. The maximum impacts from the CT would be for $PM_{2.5}$ for a limited area extending a few hundred metres east from the HTGS, but concentrations would still be below the AAQS.

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Appendix A **Comparison of MM5 Data with Meteorological Observations**

Appendix B **HTGS Plant Site Wind Roses from MM5 Meteorological Model**

Appendix C **Maximum Predicted Concentrations per Year, Source Group and HTGS Production Scenario**

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ABBREVIATION LIST

BPIP	Building Profile Input Program
CALMET	California Meteorological Model
CALPUFF	California Puff Model
CDEM	Canadian Digital Elevation Model
CO	Carbon Monoxide
COARE	Coupled Ocean Atmosphere Response Experiment (overwater boundary layer model)
DOEC	Department of Environment and Conservation
CT	Combustion Turbine
HTGS	Holyrood Thermal Generating Station
NOAA	National Oceanographic and Atmospheric Administration
NO	Nitrogen Monoxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides (NO + NO_2)
PM_t	Total Particulate Matter (includes PM_{10} and $PM_{2.5}$)
PM_{10}	Particulate Matter smaller than 10 μm in diameter (includes $PM_{2.5}$)
$PM_{2.5}$	Particulate Matter smaller than 2.5 μm in diameter (also called fine particulates)
PRIME	Plume Rise Model Enhancements (building wake effects sub-model)
SO_2	Sulphur Dioxide
US-EPA	Environmental Protection Agency (US)

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1 INTRODUCTION

In order to meet peak electricity demand in the Province, Newfoundland & Labrador Hydro (HYDRO) is considering the installation of additional generating capacity by means of a 100 MW (nominal) light oil fired combustion turbine (CT) peak-shaving production unit on the site of the existing Holyrood Thermal Generation Station (HTGS). This project is required to be registered with the Department of Environment and Conservation (DOEC), which requires plume dispersion modelling to demonstrate compliance with the provincial Ambient Air Quality Standards (AAQS) as defined in the Newfoundland & Labrador *Air Pollution Control Regulation, 2004*.

Air dispersion modelling and interpretation of results were conducted following the requirements of the DOEC defined in the following guidance documents:

- *Guideline for Plume Dispersion Modelling. GD-PPD-019.2,* Newfoundland & Labrador Department of Environment & Conservation (DOEC, 2012a).
- *Determination of Compliance with the Ambient Air Quality Standards. GD-PPD-009.4,* Newfoundland & Labrador Department of Environment & Conservation (DOEC, 2012b).

The proposed combustion turbine unit would be located southeast of the HTGS power house, in an area presently occupied by a parking lot (see Figure 1).

The CALMET/CALPUFF air dispersion modelling system was used to estimate ground level concentrations of several air contaminants (SO_2, NO_2, CO, PM_t, PM_{10} and $PM_{2.5}$) resulting from the operation of the combustion turbine unit and the adjacent HTGS station. The modelling scenarios were defined by HYDRO in consultation with the DOEC. Meteorology from a meteorological model (MM5) for the 2009-2012 period, local land use and topography were used as the main inputs for CALMET. Hourly production profiles for the years 2003 and 2004, corresponding to the highest production levels at the HTGS during the last ten years, were considered with continuous production from the combustion turbine unit from November to April inclusively. The unit chosen for this exercise has a nominal 123 MW ISO rating.

The CALMET/CALPUFF modelling system input files were provided under separate cover to the DOEC for review and validation.

The modelling methodology and modelling system set-up is described in Section 2. Production scenarios, air emission rates and source parameters are presented in Section 3. Modelling results are summarized in Section 4 and conclusions are presented in Section 5.

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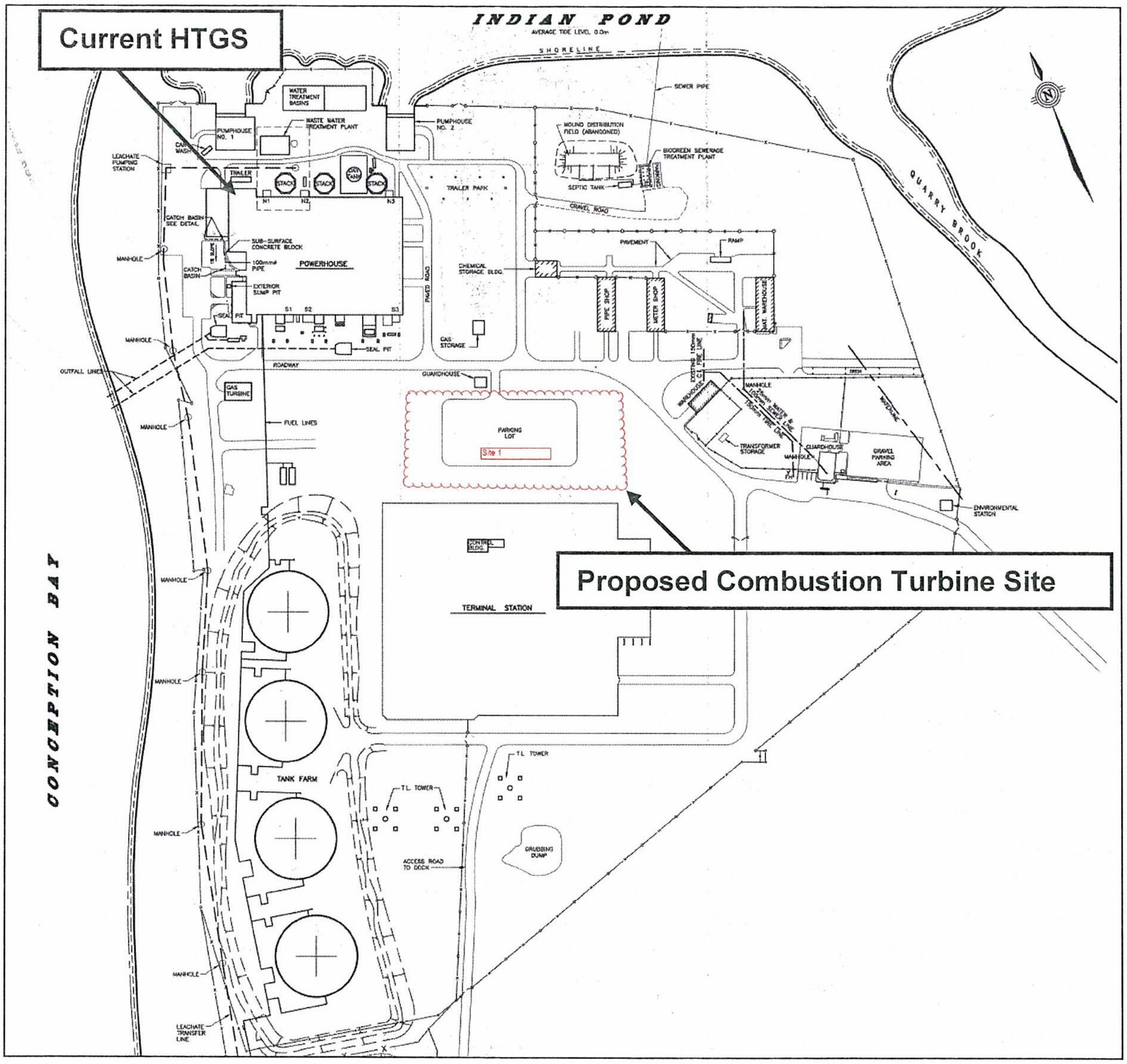
Figure 1 Overall Site Plan for the Holyrood Thermal Generating Station



2 METHODOLOGY

2.1 AIR DISPERSION MODEL

The CALMET/CALPUFF (EarthTech, 2000a, 2000b) air dispersion modelling system was used to estimate ground level concentrations of contaminants in ambient air, as per the DOEC guidance document for dispersion modelling (DOEC, 2012a). CALPUFF is an advanced non-steady-state meteorological air quality modelling system developed by the Atmospheric Science Group of TRC in the USA. CALMET is the meteorological model for CALPUFF that generates 3D meteorological fields and boundary layer parameters from hourly surface and twice daily upper air observations and/or from the hourly outputs of meteorological models. Overwater observations, from meteorological buoys or meteorological models, especially the sea-air temperature differential is also preferable for modelling in coastal regions.

The basic data required by the CALMET/CALPUFF modelling system includes:

- Gridded topographical and land use data.
- Hourly meteorological surface observations, upper air observation soundings (at least twice per day) and/or 3D meteorological fields generated by an advanced prognostic meteorological model (temperature, wind speed and direction, etc.).
- Source emission characteristics: emission rates of contaminants in the exhaust gas, the gas exit temperature and velocity, stack coordinates, configuration, diameter and height.
- Location and elevation of receptors.
- Dimensions and coordinates of buildings on-site that present wake effects causing plume downwash.

The CALPUFF model calculates the concentration of pollutants at all receptors on an hourly basis during the period under consideration. When there are multiple emission sources, the resulting concentration at each receptor is estimated by summing the individual contributions from each source. Average longer-term concentrations (3, 8 and 24 hours, 1 year) are obtained by combining the average hourly concentration at each receptor for the period.

2.2 METEOROLOGICAL DATA AND CONFIGURATION OF CALMET

2.2.1 Meteorological Domain, Topography and Land Use

CALMET was used to produce refined meteorological fields for a 25 x 25 km domain with a 250 m horizontal resolution and 11 vertical levels (top faces at: 20, 40, 80, 160, 320, 640, 1000, 1500, 2000, 2500 and 3000 metres above ground). Figure 2 presents the CALMET/CALPUFF modelling domains and the location of each HTGS ambient air monitoring station. Figure 3 presents the land use and topography over the CALMET domain.

The Canadian Digital Elevation Model (CDEM) topographic data was used to set the elevation of each cell in the domain and also to set the ground elevation of receptors. Gridded land use classifications were provided by the DOEC for the CALMET meteorological domain.

Surface characteristic parameters per land use classification and by season used in CALMET for the Avalon region are reproduced in Table 1, as provided in the plume modelling guidance document from the DOEC. For winter conditions however, the values of surface roughness for evergreen and mixed forest were modified from the guidance document values to be coherent with non-winter values (for example, 1.0 m instead of 1.3 m for evergreen forests). Table 1 only shows parameters for land use classes present in the CALMET domain.

2.2.2 Meteorological Data

For this modelling project, 3D meteorological data fields (wind, temperature, humidity, pressure and geo-potential height) covering a 50 x 50 km domain centered on the HTGS with a 4 km horizontal resolution generated by the Penn State/NCAR Mesoscale Model (MM5) for the 2009 to 2012 period were used to provide all meteorological information for CALMET. Figure 2 shows some of the MM5 grid points over the CALMET/CALPUFF domains.

The MM5 data was provided by Lakes Environmental. Lakes Environmental runs the MM5 meteorological model based on the NCEP/NCAR[1] Global Reanalysis data set (2.5 degrees resolution) using nested grids covering a much larger domain than above. The data was provided in CALMET's 3D.DAT format version 2.12, which includes sea-surface temperature and above water air temperature required for the COARE overwater boundary layer model in CALMET and hourly precipitation rates for the wet deposition model.

Local hourly observations of wind, temperature and precipitation at the Green Acres meteorological and ambient air monitoring site, located at 2.4 km to the south of the HTGS (Figure 2), were analysed and compared to the MM5 data for the HTGS location. This exercise showed good agreement between observations and modelled meteorology and that the MM5 was able to adequately reproduce the local climatology of the region. More details are presented in Appendix A. Local observations were not used as input to the modelling system because of potential problems related to a few disagreements between observations and the MM5 data or between the MM5 and CALMET sub-models (wind extrapolation primarily).

2.2.3 Local Wind Rose Diagram

Figure 4 presents the near surface (15 m) wind rose diagram for the entire meteorological period (2009-2012) derived from the MM5 modelled winds for the HTGS site. Figure 5 shows the wind rose for the high electricity demand period, i.e., CALPUFF modeling period. Dominant winds are from the southwest on an annual basis and from the west during the winter season. Appendix B presents wind rose diagrams for each year as well as seasonal and monthly average wind roses based on the MM5 data.

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[1] NCEP/NCAR Reanalysis Project is a joint project between the National Centers for Environmental Prediction (NCEP, formerly "NMC") and the National Center for Atmospheric Research (NCAR).

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Figure 2 CALMET and CALPUFF Modelling Domains, MM5 Grid Points and Air Monitoring Sites

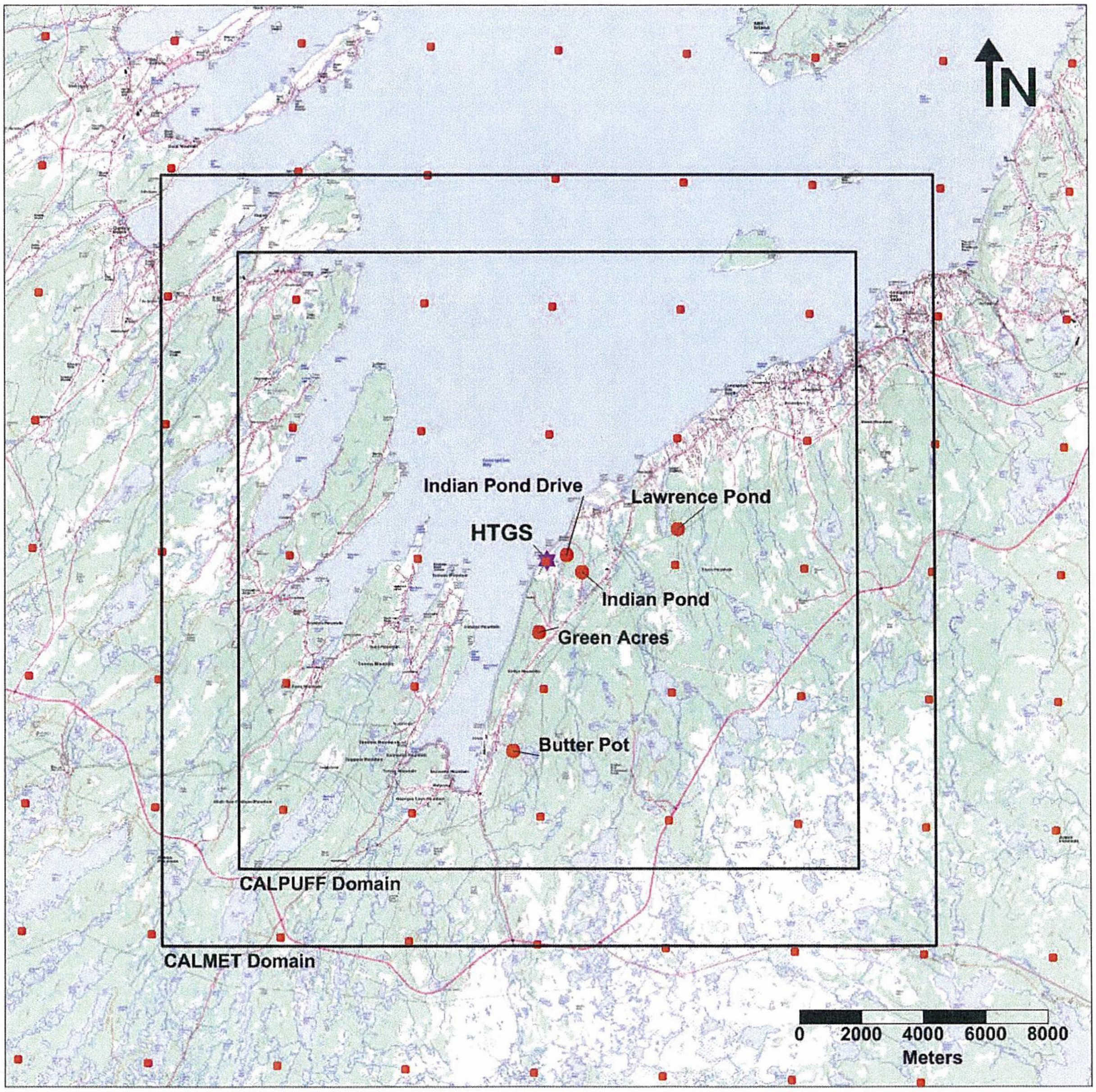

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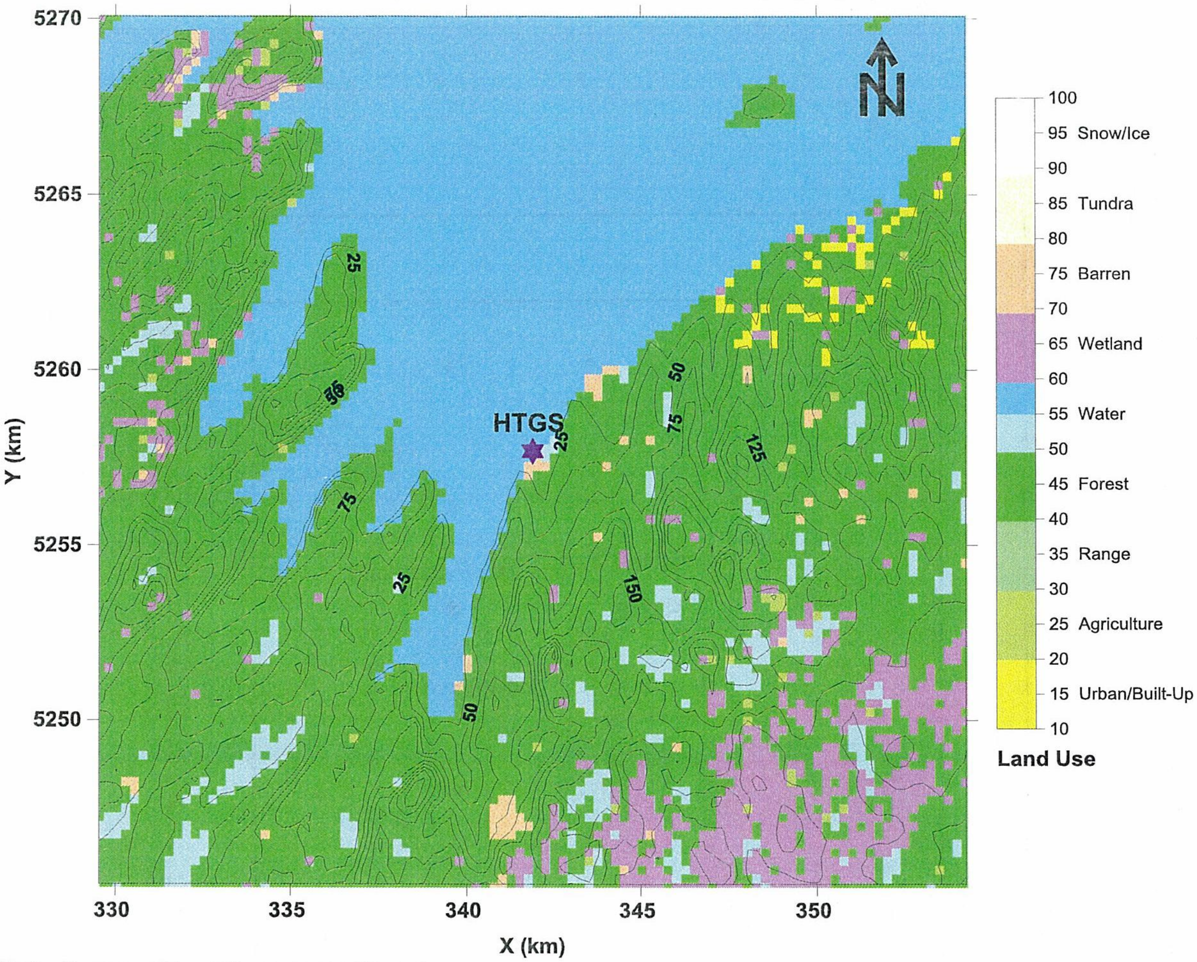
Figure 3 CALMET Modelling Domain, Land Use and Topography



Note: Topographic contours every 25 metres.

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Table 1 Surface Parameters per Land Use Class and Season used in CALMET

Land Use	z_0 (m)	Albedo	Bowen Ratio	Soil Heat Flux Parameter	Anthropogenic Heat Flux (W/m^2)	Leaf Area Index
Non-winter: May 16 to October 31.						
Residential	0.5	0.18	1.0	0.20	0.0	1.0
Herbaceous Rangeland	0.05	0.25	1.0	0.15	0.0	0.5
Shrub/Brush Rangeland	0.05	0.25	1.0	0.15	0.0	0.5
Deciduous Forest Land	1.0	0.1	1.0	0.15	0.0	7.0
Evergreen Forest Land	1.0	0.1	1.0	0.15	0.0	7.0
Mixed Forest Land	1.0	0.1	1.0	0.15	0.0	7.0
Fresh Water	0.001	0.1	0.0	1.0	0.0	0.0
Salt Water (Conception Bay)*	0.001	0.1	0.0	1.0	0.0	0.0
Non-Forested Wetland	0.2	0.1	0.1	0.25	0.0	1.0
Bare Exposed Rock	0.05	0.3	1.0	0.15	0.0	0.05
Mixed Barren Land	0.05	0.3	1.0	0.15	0.0	0.05
Winter without snow cover: April 1st to May 15th and November 1st to December 31st.						
Residential	0.5	0.18	1.0	0.20	0.0	1.0
Herbaceous Rangeland	0.01	0.2	1.0	0.15	0.0	0.5
Shrub/Brush Rangeland	0.01	0.2	1.0	0.15	0.0	0.5
Deciduous Forest Land	0.6	0.17	1.0	0.15	0.0	7.0
Evergreen Forest Land	1.0	0.12	0.8	0.15	0.0	7.0
Mixed Forest Land	0.77	0.14	0.9	0.15	0.0	7.0
Fresh Water	0.001	0.1	0.0	1.0	0.0	0.0
Salt Water (Conception Bay)*	0.001	0.1	0.0	1.0	0.0	0.0
Non-Forested Wetland	0.2	0.14	0.1	0.25	0.0	1.0
Bare Exposed Rock	0.05	0.2	1.5	0.15	0.0	0.05
Mixed Barren Land	0.05	0.2	1.5	0.15	0.0	0.05
Winter with snow cover: January 1st to March 31st.						
Residential	0.5	0.45	0.5	0.15	0.0	1.0
Herbaceous Rangeland	0.005	0.7	0.5	0.15	0.0	0.5
Shrub/Brush Rangeland	0.005	0.7	0.5	0.15	0.0	0.5
Deciduous Forest Land	0.5	0.5	0.5	0.15	0.0	0.0
Evergreen Forest Land	1.0	0.35	0.5	0.15	0.0	7.0
Mixed Forest Land	0.71	0.42	0.5	0.15	0.0	3.5
Fresh Water	0.001	0.7	0.5	0.15	0.0	0.0
Salt Water (Conception Bay)*	0.001	0.7	0.5	0.15	0.0	0.0
Non-Forested Wetland	0.2	0.6	0.5	0.15	0.0	0.0
Bare Exposed Rock	0.002	0.7	0.5	0.15	0.0	0.0
Mixed Barren Land	0.002	0.7	0.5	0.15	0.0	0.0

* Overwater boundary layer sub-model is used for this land use class, surface parameters are not used.

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Figure 4 Annual Wind Rose at the HTGS Site from the MM5 Data (2009-2012)

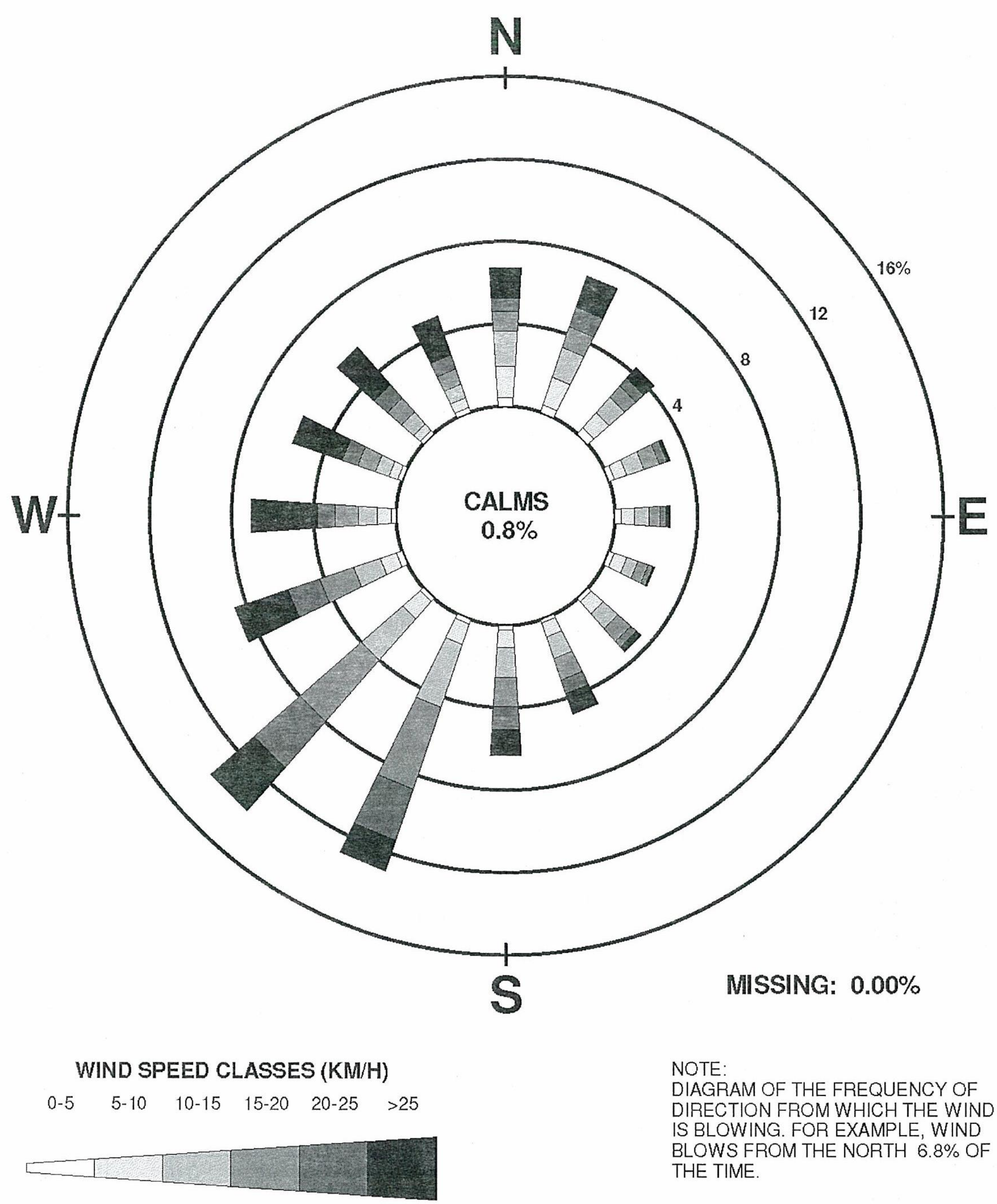

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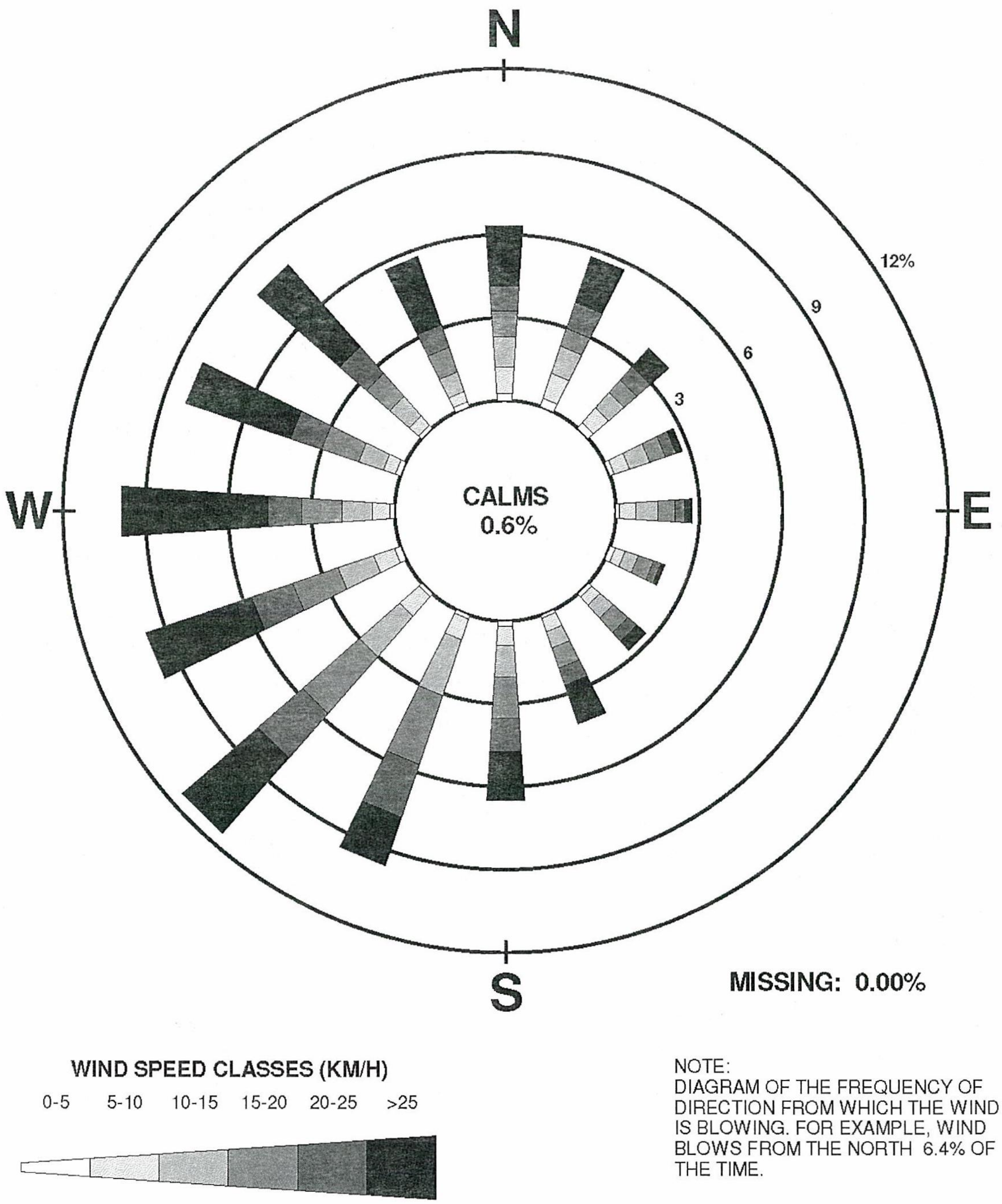
Figure 5 November to April Wind Rose at the HTGS Site from the MM5 Data (2009-2012)



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2.2.4 CALMET Options and Generation of Meteorological Fields

In general, most default CALMET options were selected, with the exception of options related to the use of a data set from a weather model and coastal effects. The wind field calculations were initialised using the MM5 data.

All non default CALMET selected options are listed in Table 2.

Table 2 CALMET Configuration - Non Default CALMET Options

CALMET options	Selected non default option values	
No observation mode	NOOBS = 2	No surface, overwater, or upper air observations Use MM4/MM5/3D.DAT for surface, overwater, and upper air data
Cloud data option	ICLOUD = 4	Gridded cloud cover from prognostic relative humidity at all levels
Relative humidity option	IRHPROG = 1	3D relative humidity from prognostic data
Precipitation option	ICLOUD = 4	Gridded cloud cover from prognostic relative humidity at all levels
Spatial averaging search radius	MNMDAV = 4	Temperature and mixing height spatial averaging is based on a 4 grid cell distance (4 x 250 m =1 km)
Wind Field Options*		
Use gridded prognostic wind field model output fields as input to the diagnostic wind field model	IPROG = 14	Yes, use winds from MM5/3D.DAT file as initial guess field.
Radius of influence of terrain features	TERRAD = 5 (no default)	Terrain effects are considered up to 5 km for each grid point.
Temperature Field Options		
3D temperature from observations or from prognostic data	ITPROG = 2	No surface or upper air observations. Use MM5/3D.DAT for surface and upper air data.
Land use categories for temperature interpolation over water	JWAT1= 55 JWAT2= 55	Temperature overwater for land use code 55 (salty water, Conception Bay) will be based on MM5 overwater air temperatures.
Overwater Options		
Option for overwater lapse rates used in convective mixing height growth	ITWPROG = 2	Use prognostic lapse rates and prognostic delta T.
Land use categories for using the overwater boundary layer sub model	IWAT1= 55 IWAT2= 55 (defined in GEO.DAT)	For land use code 55 (salty water, Conception Bay) the overwater boundary layer sub model will be used.

* Wind field generation parameters (R1, R2, RMAX1, RMAX2, RMAX3, RMIN, and LVARY) are irrelevant when no observation mode is used.

2.3 CONFIGURATION OF CALPUFF

2.3.1 Receptors

A nested grid pattern covering a 20 x 20 km domain that exceeds the general requirements of the DOEC plume dispersion modelling guidelines was used for the receptors:

- 50 metre spacing from the centre of the operation out to 1 km;
- 100 metre spacing from 1 km out to 2 km;
- 200 metre spacing from 2 km out to 3 km;
- 500 metre spacing from 4 km out to 10 km.

Additional receptors were placed at a finer resolution every 20 metres along the property line and at the five HTGS air quality monitoring sites listed in Table 3, for a total of 5,083 receptor points located at ground level (flagpole height at zero). The receptor grids and additional receptors are shown on Figure 6.

Table 3 Air Quality Monitoring Sites

Air Quality Monitoring Sites	UTM coordinates (NAD 83, Zone 22)		From HTGS	
	Easting(m)	Northing (m)	Distance (km)	Direction
Lawrence Pond	346,116	5,258,700	4.3	ENE
Green Acres (met station)	341,617	5,255,352	2.4	S
Butter Pot	340,783	5,251,500	6.3	S
Indian Pond	343,039	5,257,305	1.2	ESE
Indian Pond Drive	342,526	5,257,851	0.6	ENE

2.3.2 Building Wake Effects

Building wake effects on plume rise and atmospheric dispersion were considered within CALPUFF. Building dimensions and stack heights (presented in Section 3) were processed with the Building Profile Input Program (BPIP) to generate the characteristic dimensions required by CALPUFF's PRIME building wake sub model.

2.3.3 Special CALPUFF Options

CALPUFF default options were used in the model configuration, with the exceptions presented in Table 4 as required by the DOEC modelling guidance document.

2.3.4 Chemical transformation, deposition and particulates classes

For chemical transformation modelling, the monthly background concentration values for ozone, ammonia and H_2O_2 recommended in the DOEC's plume modelling guidance document were used and are presented in Table 5. For wet and dry deposition of gaseous and particulate species, default values found in the CALPUFF libraries were used and are listed in Tables 6 to 8.

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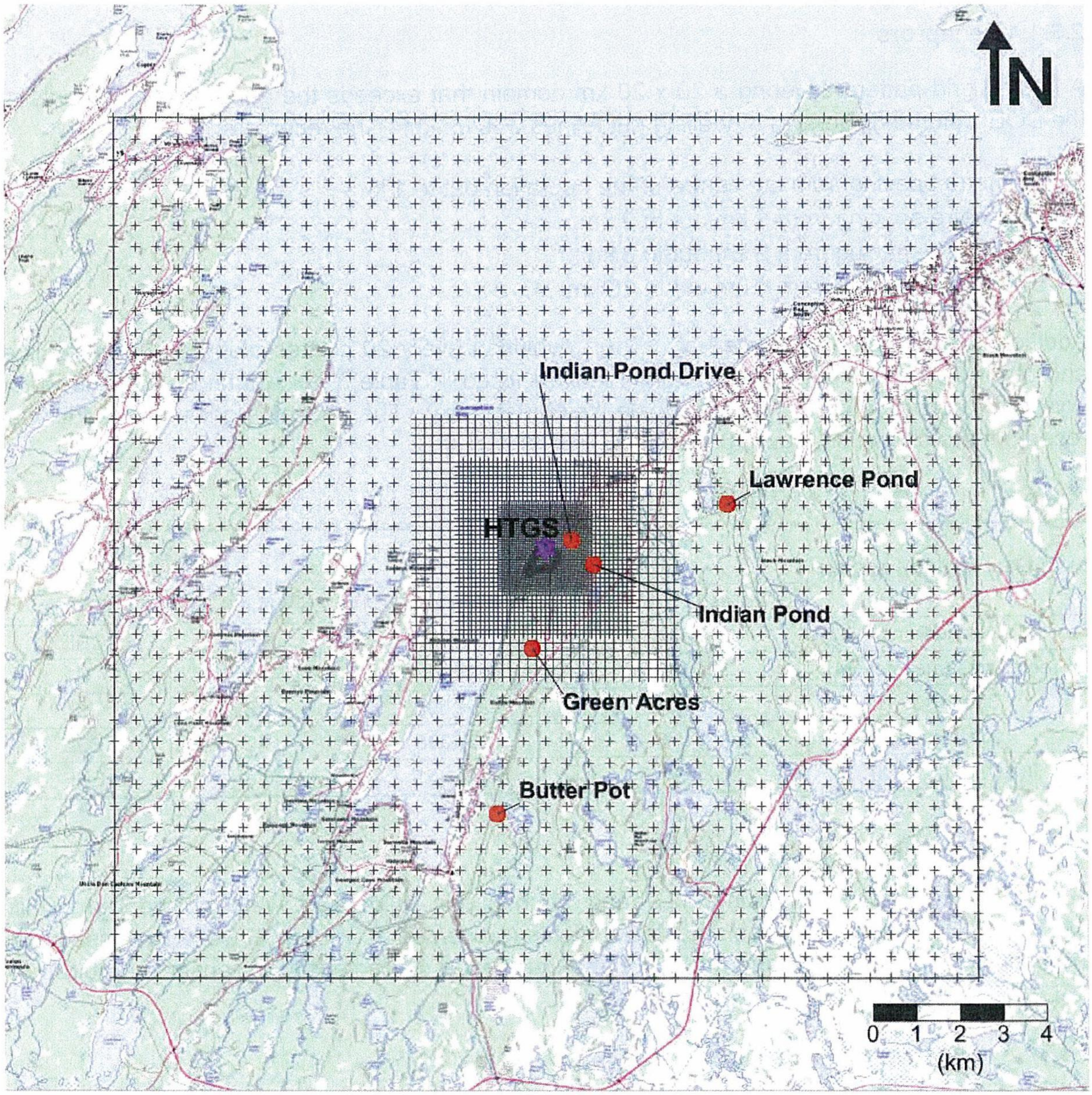
Figure 6 Receptor Grids and Discrete Receptors over the Modelling Domain



Finally, following the DOEC's requirements, particulate emissions were modelled as three distinct size groups (P1, P2 and P3) as defined in Table 6 and the CALPUFF default particulate density of 1 g/m³ was also considered. The POSTUTIL utility was used to obtain PM_t, PM_{10} and $PM_{2.5}$ concentrations in the following way

$$PM_{2.5} = P1$$
$$PM_{10} = P1 + P2$$
$$PM_t = P1 + P2 + P3$$

Table 4 CALPUFF Configuration - Non Default CALPUFF Options

Parameter	Name of parameter and interpretation	Default value	Selected value (1)	Selected value interpretation
NSE	Number of emitted species	3	7 (2)	Emitted species (3)
NSPEC	Number of chemical species	5	10 (2)	Emitted species and species implicated in chemical transformations (4)
MBDW	Method used to simulate building downwash	1	2	PRIME method
MSPLIT	Puff splitting allowed	0	1	Yes
MCHEM	Chemical mechanism	1	6	Updated RIVAD scheme with ISORROPIA equilibrium
MAQCHEM	Aqueous phase transformation	0	1	Transformation rates and wet scavenging coefficients adjusted for in-cloud aqueous phase reactions
MLWC	Liquid water content	1	0	Water content estimated from cloud cover and presence of precipitation
MDISP	Method used to compute dispersion coefficients	3	2	Dispersion coefficients from internally calculated micrometeorological variables
MPDF	Probability density function (PDF) used for dispersion under convective conditions	0	1	Yes
MREG	Test options specified to verify if they conform to (US-EPA) regulatory values	1	0	No checks are made
MOZ	Ozone data input option	1	0	Monthly background value
MH2O2	H_2O_2 data input option	1	0	Monthly background value
NINT	Number of particle size intervals	9	5	Used to evaluate effective particle deposition velocity

(1) DOEC requirements or recommended values.
(2) Project specific values.
(3) Emitted species: SO_2, NO, NO_2, CO and PM divided into three class sizes (P1 (d < 2.5 µm), P2 (2.5 µm <d < 10 µm), P3 (d > 10 µm)).
(4) Emitted species plus species implicated in NOx/SOx chemistry: SO_4, NO_3, HNO_3.

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Table 5 Monthly Background Concentrations for RIVAD/ISORROPIA Chemistry

Month	Ozone (O_3) (ppb)	Ammonia (NH_3) (ppb)	Hydrogen Peroxide (H_2O_2) (ppb)
January	32	0.5	0.2
February	34	0.5	0.2
March	37	0.5	0.2
April	38	0.5	0.2
May	32	0.5	0.2
June	26	0.5	0.2
July	23	0.5	0.2
August	21	0.5	0.2
September	23	0.5	0.2
October	25	0.5	0.2
November	28	0.5	0.2
December	31	0.5	0.2

Table 6 Dry Deposition Parameters for Modelled Particulate Species

Modelled Particulate Species	Geometric Mass Mean Diameter (µm)	Geometric Standard Deviation (µm)
SO_4	0.48	2.0
NO_3	0.48	2.0
P1 (d < 2.5 µm)	1.25	1.242
P2 (2.5 µm < d < 10 µm)	5.0	1.242
P3 (d >10 µm)	20.0	1.242

Table 7 Dry Deposition Parameters for Modelled Gaseous Species

Modelled Gaseous Species	Diffusivity (cm^2/s)	Alpha Star	Reactivity	Mesophyllic Resistance (s/cm)	Henry's Law Coefficient (dimensionless)
SO_2	0.1509	1000	8	0	0.04
HNO_3	0.1628	1	18	0	8.0×10^{-8}
NO	0.1345	1	2	25	18
NO_2	0.1656	1	8	5	3.5
CO	0.1860	1	2	61	44

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Table 8 Wet Deposition Parameters for Modelled Species

Modelled Species (G:gas, P:particulate)	Scavenging Coefficient (s^{-1})	
	Liquid Precipitation	Frozen Precipitation
SO_2 (G)	3.00×10^{-5}	0.0
SO_4 (P)	1.00×10^{-4}	3.00×10^{-5}
HNO_3 (G)	6.00×10^{-5}	0.0
NO_3 (P)	1.00×10^{-4}	3.00×10^{-5}
NO (G)	0.0	0.0
NO_2 (G)	0.0	0.0
CO (G)	0.0	0.0
P1 (P)	6.03×10^{-5}	2.01×10^{-5}
P2 (P)	3.54×10^{-4}	1.18×10^{-4}
P3 (P)	6.64×10^{-4}	2.21×10^{-4}

3 EMISSIONS SCENARIOS AND PARAMETERS

3.1 Emissions Scenarios

Two scenarios including the three existing sources at the HTGS along with the proposed combustion turbine production unit were considered. The first scenario is based on the 2003 HTGS hourly production profiles and the second is based on the 2004 HTGS hourly production profiles. Years 2003 and 2004 represent the top production years at the HTGS during the last ten year period. For both scenarios, a constant full load is considered for the combustion turbine unit. Only the high electricity demand season from November 1st to April 30th for each of the meteorological data years (2009 to 2012) was considered in the simulations.

3.2 Air Emissions

For the HTGS sources, emission factors (grams of pollutant per kilogram of fuel) were derived from the latest stack tests (ATS, 2014) performed in November 2013 in combination with the corresponding fuel consumption. The SO_2 emission factor is based on a fuel sulphur mass balance considering a 0.7 % by mass sulphur content in the fuel. These emission factors are presented in Table 9 with the physical characteristics of the HTGS stacks.

The HTGS emission factors were then used to estimate hourly emission rates based on process data (fuel flow (kg/s), flue gas flow (kg/s) and temperature per unit) for the 2003 and 2004 production scenarios.

For the combustion turbine unit, the technical specifications and emission rates were provided by the manufacturer. The emission rates and parameters for an ambient temperature of 20°F are presented in Table 10. The SO_2 emission rate is based on a fuel sulphur mass balance that considers 0.05% by mass sulphur content in the fuel. PM emissions are reported to be PM_{10} and in the absence of specific data for $PM_{2.5}$, all PM emissions were considered as $PM_{2.5}$, which represents a worst case scenario.

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CALPUFF runs were performed for the HTGS alone for both production profiles, for the CT alone and for the HTGS and the CT together for both production profiles, for a total of five runs, each for 4 year period. For each CALPUFF run, distinct *Point Source Emissions Files with Arbitrarily Varying Emissions* (PTEMARB.DAT) were prepared for input to CALPUFF.

3.3 Building Dimensions and Stack Locations

Figure 7 presents a schematic layout of the HTGS and CT unit main buildings and stacks. These buildings were considered in the wake effect analysis with BPIP and their heights are also indicated on the figure. For north-westerly winds, the combustion turbine unit would be in the far range of the main HTGS building wake. Note that the HTGS fuel tanks located southwest of the HTGS (Figure 1) were also considered, but the BPIP analysis showed that wakes generated by those structures would not reach the CT unit and affect the CT plume.

Table 9 HTGS Sources: Unit 1, Unit 2 and Unit 3 Characteristics

Parameter	Unit 1	Unit 2	Unit 3
East (X in km) – UTM zone 22, WGS-84	341.881	341.903	341.933
North (Y in km) – UTM zone 22, WGS-84	5,257.701	5,257.686	5,257.667
Stack base elevation (mean sea level) (m)	10	10	10
Height (m)	91.44	91.44	109.72
Diameter (m)	4.115	4.115	3.048
Temperature (K) (1), typical values	Hourly 466 - 479	Hourly 463 - 473	Hourly 442 - 449
Exit velocity (m/s) (1), typical values	Hourly 16 -18	Hourly 16 - 18	Hourly 19 - 21
Emission factors (1),(2)			
SO_2 emission factor (g/kg fuel)	14.0	14.0	14.0
NO emission factor (g/kg fuel)	2.25	2.65	5.05
NO_2 emission factor (g/kg fuel)	0.0400	0.0500	0.180
CO emission factor (g/kg fuel)	0.0215	0.00157	0.000992
PM_t emission factor (g/kg fuel)	0.842	0.390	0.573
PM_{10} emission factor (g/kg fuel)	0.569	0.265	0.573
$PM_{2.5}$ emission factor (g/kg fuel)	0.450	0.205	0.511

(1) Hourly temperature, velocity and emission rates are based on hourly temperatures, flue gas and fuel consumption data.
(2) Emission factors are based on measurement during Source Emissions Testing in November 2013 (ATS, 2014).

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Table 10 Combustion Turbine Characteristics – Manufacturer's Data

Parameter	100 % load (134 MW)
East (X in km) – UTM zone 22, WGS-84	341.941
North (Y in km) – UTM zone 22, WGS-84	5,257.458
Stack base elevation (mean sea level) (m)	13
Height (m)	15.2
Diameter (m)(1)	7.65
Temperature (K)	782
Exit velocity (m/s)	21.0
SO_2 emission rate (g/s)	9.71
NO emission rate (g/s) (2)	8.05
NO_2 emission rate (g/s) (2)	18.5
CO emission rate (g/s)	4.03
PM_t, PM_{10}, $PM_{2.5}$ emission rate (g/s) (3)	6.39

(1) The rectangular stack was represented by a circular stack with an equivalent surface area.
(2) The NO_2 emission rate is estimated based on a 0.6 NO_2 to NO_x volume ratio as required for combustion turbines in the Guideline for Plume Dispersion Modelling of the DOEC.
(3) For modelling purposes, it was assumed that all PM falls in the $PM_{2.5}$ category.

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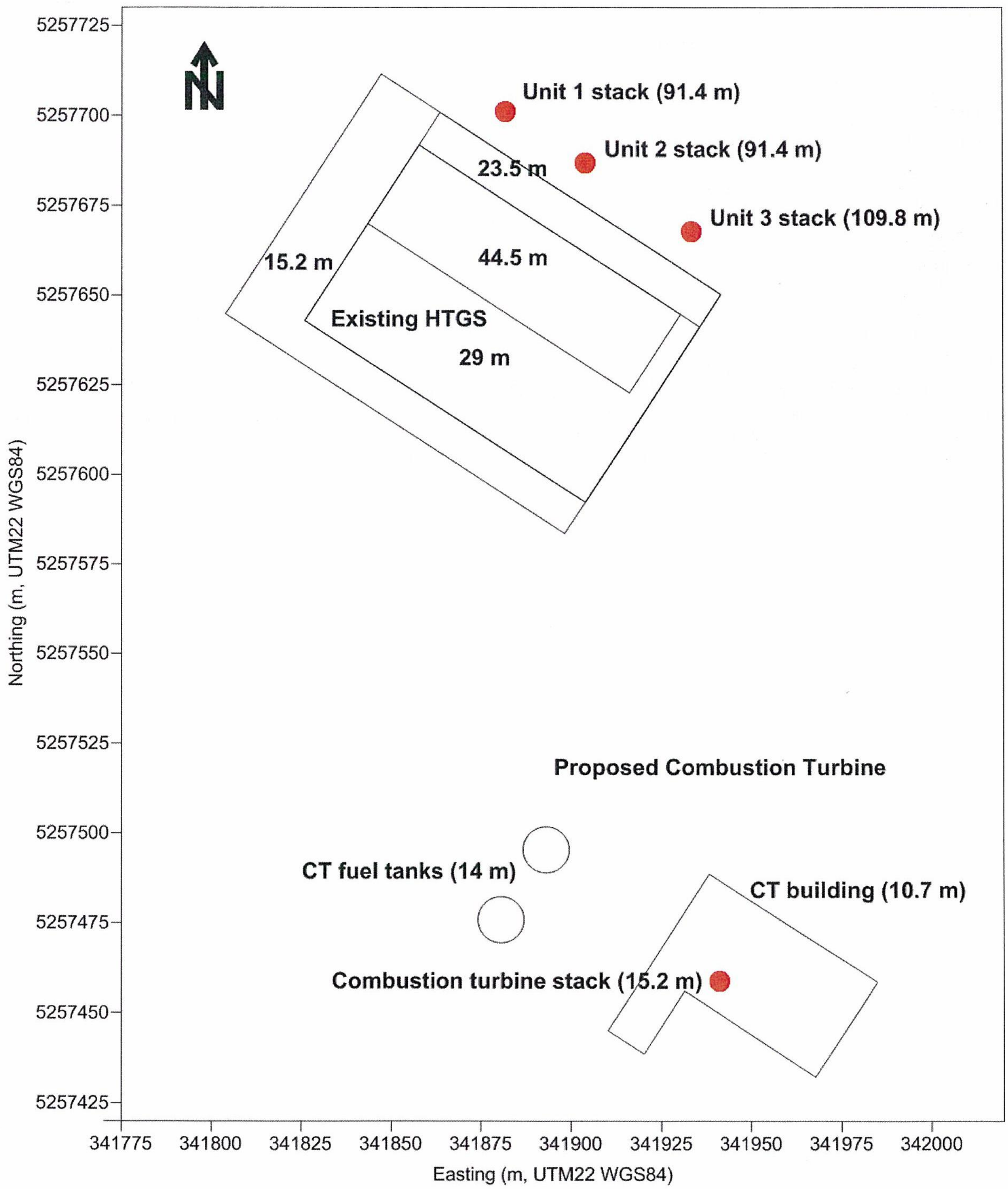
Figure 7 Physical Building Characteristics – HTGS and Combustion Turbine



4 RESULTS AND DISCUSSION

This section presents the CALPUFF modelling results at and beyond the HTGS property fence line and over the whole receptor domain.

4.1 Dispersion Modelling Results Interpretation

As per the DOEC guidance document for determination of compliance (DOEC, 2012b), compliance for modelled impacts for any given year was based on the following:

- 9^{th} highest level at any given receptor for a 1-hour averaging period;
- 6^{th} highest level at any given receptor for a 3-hour averaging period;
- 3^{rd} highest level at any given receptor for a 8-hour averaging period;
- 2^{nd} highest level at any given receptor for a 24-hour averaging period;
- 1^{st} highest level at any given receptor for an annual averaging period.

All results presented in the next sections are based on the above interpretation.

As the HTGS and proposed CT unit are located in a rural setting, the DOEC recommended that all background concentrations would be negligible for all the pollutants (i.e. zero). Therefore, modelling results are directly compared with AAQS in the following sections.

4.2 Summary of Maximum Predicted Concentrations

Table 11 presents a summary of maximum predicted concentrations for both source groups individually (HTGS and CT) and all sources combined showing the before and after project impacts and the maximum contributions of the CT unit itself. The results in Table 11 are for the entire 4 year modelling period (2009-2012). Results per year, source group and the HTGS production scenario are presented in Appendix C.

All modelling results are in compliance with the AAQS for all contaminants (SO_2, NO_2, CO, PM_t, PM_{10} and $PM_{2.5}$) and averaging periods (1-hour, 3-hour, 8-hour, 24-hour and annual).

The maximum contributions relative to the AAQS of the CT unit vary significantly depending on contaminants and averaging periods. The same assertion also applies to the net increase in predicted maximum concentrations when comparing results for the HTGS alone to the HTGS and CT scenarios. Note also that the CT unit was considered at full load during the entire modelling period, which is an unrealistic situation for a peak-shaving production unit. The CT unit should be online only during peak demand hours when sufficient generation capacity is not available from the HTGS alone..

For SO_2, the CT maximum contributions are much lower than the contributions of the HTGS. The maximum predicted concentrations with and without the presence of the CT unit are virtually the same, meaning that maximum impacts from the combustion turbine production unit are much lower than from the HTGS and that these maximum contributions do not occur during the same conditions and at the same receptors.

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Table 11 Summary of CALPUFF Maximum Annual Predicted Concentrations over All Receptors for Source Groups and HTGS Production Scenarios

HTGS 2003 Production Scenario								
Pollutant	Period	HTGS Alone		CT Alone		HTGS+CT		AAQS
		Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	
SO_2	1 h	536	60%	41	5%	550	61%	900
	3h	461	77%	36	6%	463	77%	600
	24 h	296	99%	25	8%	297	99%	300
	Annual	7.0	12%	0.5	1%	7.1	12%	60
NO_2	1h	145	36%	94	23%	153	38%	400
	24 h	70	35%	56	28%	80	40%	200
	Annual	2.2	2.2%	1.2	1.2%	2.4	2%	100
CO	1h	0.43	0.0012%	17	0.048%	17	0.048%	35,000
	8 h	0.27	0.0018%	13	0.085%	13	0.085%	15,000
PM_t	1 h	23		27		28		n/a
	24 h	12	10%	16	14%	16	14%	120
	Annual	0.29	0.48%	0.34	0.56%	0.35	0.58%	60
PM_{10}	1h	18		27		27		n/a
	24 h	9.2	18%	16	33%	16	33%	50
	Annual	0.22		0.34		0.34		n/a
$PM_{2.5}$	1 h	15		27		27		n/a
	24 h	7.5	30%	16	65%	16	65%	25
	Annual	0.18		0.34		0.34		n/a
HTGS 2004 Production Scenario								
Pollutant	Period	HTGS Alone		CT Alone		HTGS+CT		AAQS
		Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	
SO_2	1 h	663	74%	41	4.5%	663	74%	900
	3h	413	69%	36	5.9%	413	69%	600
	24 h	234	78%	25	8.3%	234	78%	300
	Annual	7.0	12%	0.51	0.8%	7.1	12%	60
NO_2	1h	220	55%	94	23%	220	55%	400
	24 h	62	31%	56	28%	68	34%	200
	Annual	2.2	2.2%	1.2	1.2%	2.4	2.4%	100
CO	1h	0.46	0.001%	17	0.048%	17	0.048%	35,000
	8 h	0.23	0.002%	13	0.085%	13	0.085%	15,000
PM_t	1 h	27		27		29		n/a
	24 h	10	8.3%	16	14%	16	14%	120
	Annual	0.30	0.51%	0.34	0.56%	0.36	0.60%	60
PM_{10}	1h	22		27		27		n/a
	24 h	7.2	14%	16	33%	16	33%	50
	Annual	0.23		0.34		0.35		n/a
$PM_{2.5}$	1 h	19		27		27		n/a
	24 h	5.9	24%	16	65%	16	65%	25
	Annual	0.19		0.34		0.34		n/a

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For all other contaminants, modelling results show a net increase in predicted maximum concentrations over all receptors. These increases are marginal for NO_2 and more significant for CO and PM (especially $PM_{2.5}$). For CO, concentrations remain extremely low compared to the AAQS. For daily $PM_{2.5}$, the maximum prediction concentration over the entire domain is totally dominated by the CT unit contribution.

To better understand the variation in the relative contribution of source groups to the overall maximum, two characteristics of the sources must be considered: emissions characteristics and relative pollutant emissions rates.

Compared to the HTGS boiler units, the single cycle CT unit emissions are characterized by a large flow of flue gas at high temperature (510°C). Even if the CT unit stack height is low (15 m), the high momentum and buoyancy of the plume can make it reach a much higher elevation than the HTGS plume. For one of the most common meteorological conditions (neutral stability D and a 4 m/s wind velocity), the estimated plume heights[2] are 260 m (above ground) for the HTGS units and 860 m for the CT unit. In many situations, the plume from the CT could rise above the mixing height leading to very low ground level impacts while the HTGS plumes could remain below the mixing height leading to increases in ground level concentrations of contaminants. At high wind velocities (> 50 km/h), the plume from the CT unit will remain below the plume of the HTGS. Under these conditions, plume heights would only be slightly higher than stack heights. These observations are sufficient to explain why maximum contributions from both sources are not additive, i.e., they do not occur during the same conditions and at the same location.

Table 12 presents the total maximum emission rates of contaminants for the HTGS and the CT unit. From this table and the previous discussion, it is quite clear why the HTGS is the dominant source for maximum ground level concentrations of SO_2 and why the CT unit dominates for CO. For other contaminants, maximum contributions from both source groups simply do not occur at the same location and under the same meteorological conditions that affect plume heights.

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[2] Using the simple US-EPA SCREEN3 dispersion model

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Table 12 Maximum Emissions per Source Group

Contaminants	HTGS Max 3 units (g/s)	CT 100% load (g/s)	CT Increase
SO_2	420	9.71	2.3%
NO_x (as NO_2)	155	30.9	19.9%
CO	0.250	4.03	1612.0%
PM_t	18.0	6.39	35.5%
PM_{10}	14.1	6.39	45.4%
$PM_{2.5}$	11.7	6.39	54.8%

4.3 RESULTS OVER THE MODELLING DOMAIN

The previous section focussed on the maximum predicted concentrations over the modelling domain and showed compliance with the AAQS. These maximum concentrations do not occur over the entire modelling domain and are localised at specific locations. They also do not occur very frequently. This section presents maximum concentrations for SO_2 for different averaging periods, hourly NO_2 and daily $PM_{2.5}$ over a part of the modelling domain. These contaminants were selected because they reach the highest levels relative to the AAQS.

4.3.1 Sulphur Dioxide (SO_2)

Figures 8 to 13 present maximum hourly, daily and annual predicted concentrations over a part of the modelling domain for all sources (HTGS+CT) combined and for both HTGS production scenarios.

For hourly predicted SO_2 concentrations, Figures 8 and 9 show that maximum predicted concentrations (400 to 600 µg/m³) occur in elevated terrain across Conception Bay at 6 km west of the HTGS and at a distance of 1 to 2 km to the east and south of the HTGS. For most of the modelling domain, maximum predicted concentrations are in the 100 to 200 µg/m³ range, much lower than the AAQS (900 µg/m³).

For daily concentrations, Figures 10 and 11 show that the maximum predicted concentrations occur about 1 km east of the HTGS with maximum values above 200 µg/m³ for relatively small areas, but below the AAQS (300 µg/m³). Some hot spots with maximum predicted concentrations over 100 µg/m³ are also shown in elevated terrain further from the HTGS.

For annual concentrations, Figures 12 and 13 show that the maximum predicted concentrations occur 1 to 2 km east of the HTGS, which is consistent with the winter season wind rose presented in Figure 5.

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4.3.2 Nitrogen Dioxide (NO_2)

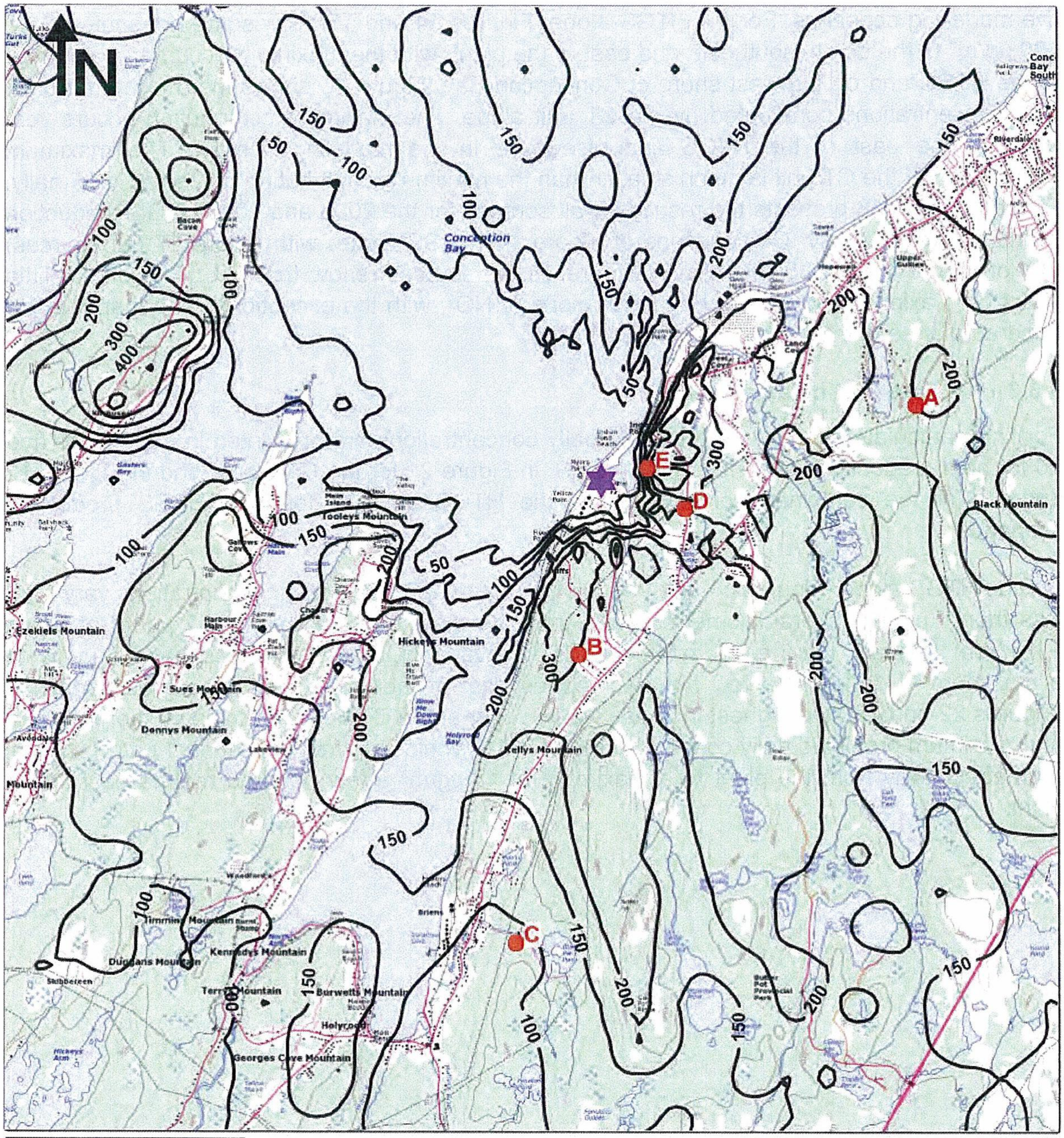
Figures 14 to 18 present the maximum predicted hourly concentrations of NO_2 for each of the five modelling scenarios. For the HTGS alone, Figures 14 and 15 show some hot spots above 100 µg/m³ to the south, southeast and east of the plant, with the maximum occurring 6 km west of the HTGS and on the west shore of Conception Bay. Figure 16 shows the maximum hourly NO_2 concentrations contributed by the CT unit alone. The maximum contribution occurs very close to the east of the HTGS and elsewhere in the modeling domain. The maximum contribution of the CT unit is much smaller than the maximum contribution of the HTGS. Finally, Figures 17 and 18 presents the results for all sources for the 2003 and 2004 HTGS production scenarios, respectively. Comparisons of Figure 14 (HTGS alone) with Figure 17 (all sources) and of Figure 15 (HTGS alone) with Figure 18 (all sources) show that the CT has very little effect on maximum ground level concentrations of NO_2, with the exception of a hot spot a few hundred metres to the east of the HTGS.

4.3.3 Fine Particulates ($PM_{2.5}$)

For fine particulates, maximum predicted daily concentrations are presented in Figures 19 and 20 for both production scenarios of the HTGS, in Figure 21 for the CT alone, and in Figures 22 and 23 for the combined contributions of the HTGS and CT for both HTGS production scenarios.

For the HTGS alone (Figures 19 and 20), the maximum daily predicted concentrations vary from less than 1 µg/m³ several kilometres away from the plant to a maximum of 7 µg/m³ at about 1 km from the plant. For the CT unit (Figure 21), the variation ranges from less than 0.5 µg/m³ to a maximum of 16 µg/m³ a few hundred metres east of the plant. For all sources combined (Figures 22 and 23), the highest increase would occur at the CT hot spot to the east of the plant and maximum predicted daily concentrations of $PM_{2.5}$ would vary from less than 1 µg/m³ several kilometres away from the plant to a maximum of 16 µg/m³ a few hundred metres east of the plant.

Figure 8 Maximum Annual Hourly Predicted Concentration (µg/m³) of SO_2 in Ambient Air for the HTGS 2003 Production Scenario and the Combustion Turbine



Monitoring Sites
A: Lawrence Pond
B: Green Acres
C: Butter Pot
D: Indian Pond
E: Indian Pond Drive

0 1 2 3 4
(km)

AAQS: 900 µg/m³

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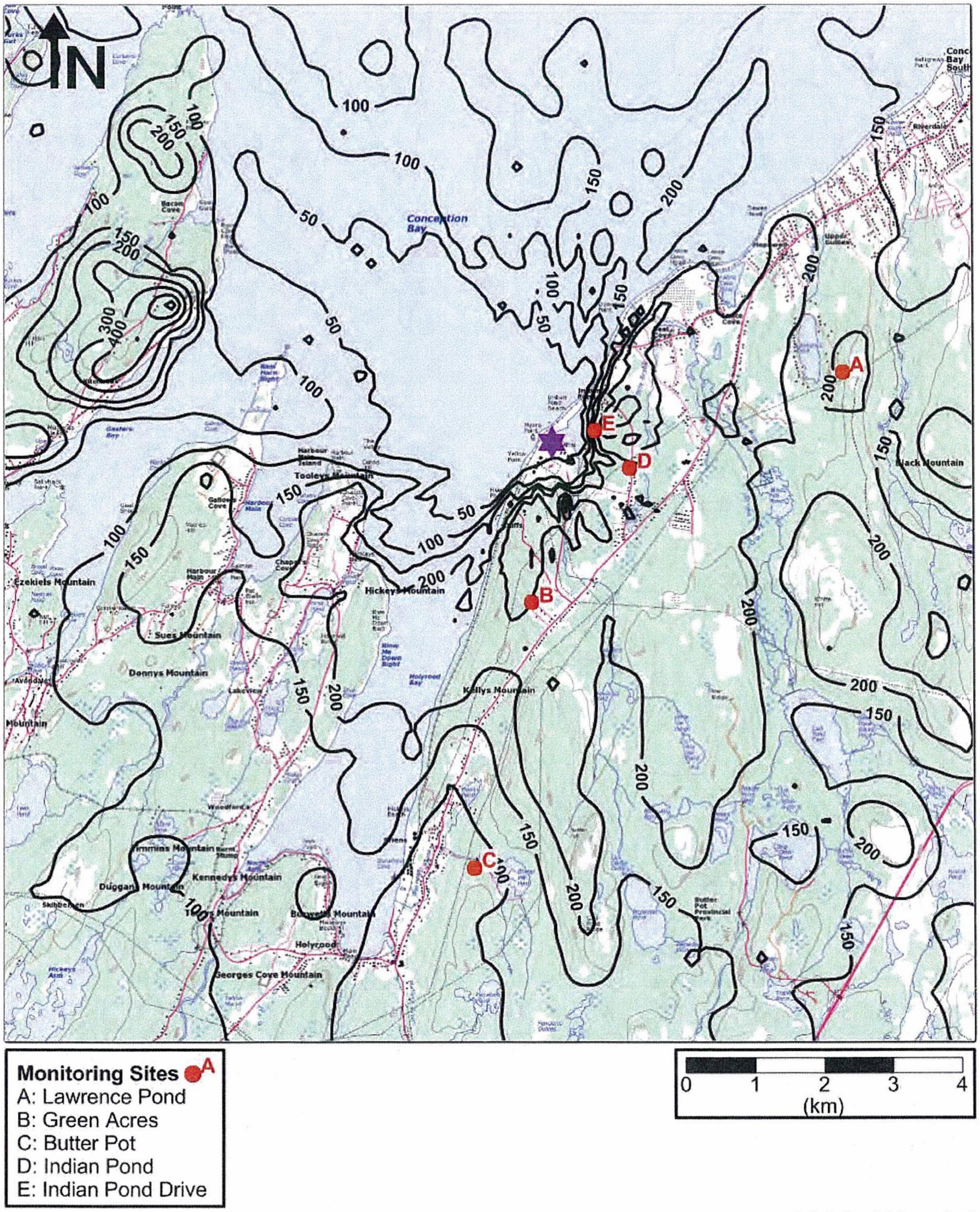
Figure 9 Maximum Annual Hourly Predicted Concentration (µg/m³) of SO_2 in Ambient Air for the HTGS 2004 Production Scenario and the Combustion Turbine



AAQS: 900 µg/m³

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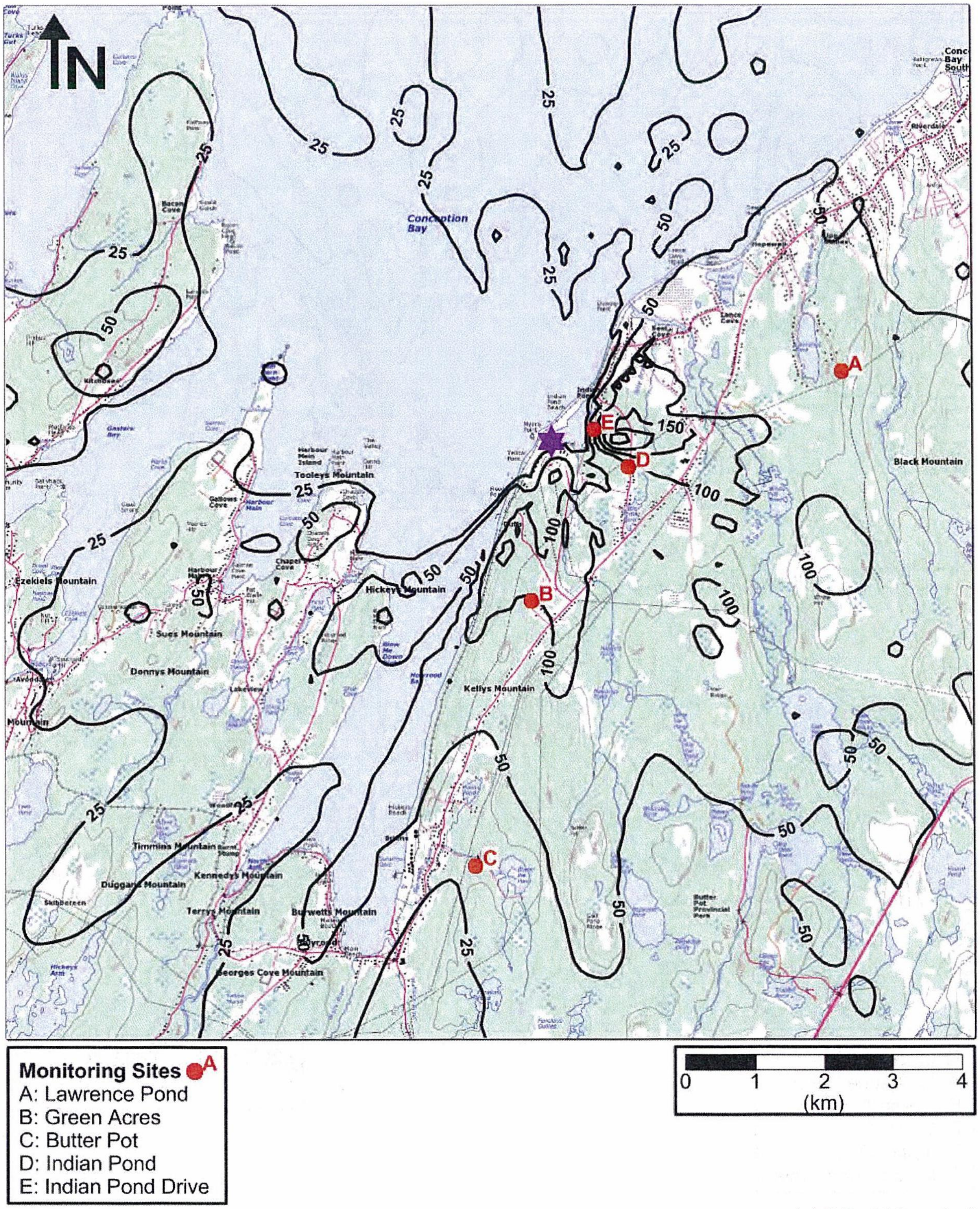
Figure 10 Maximum Annual Daily Predicted Concentration (µg/m³) of SO_2 in Ambient Air for the HTGS 2003 Production Scenario and the Combustion Turbine



AAQS: 300 µg/m³

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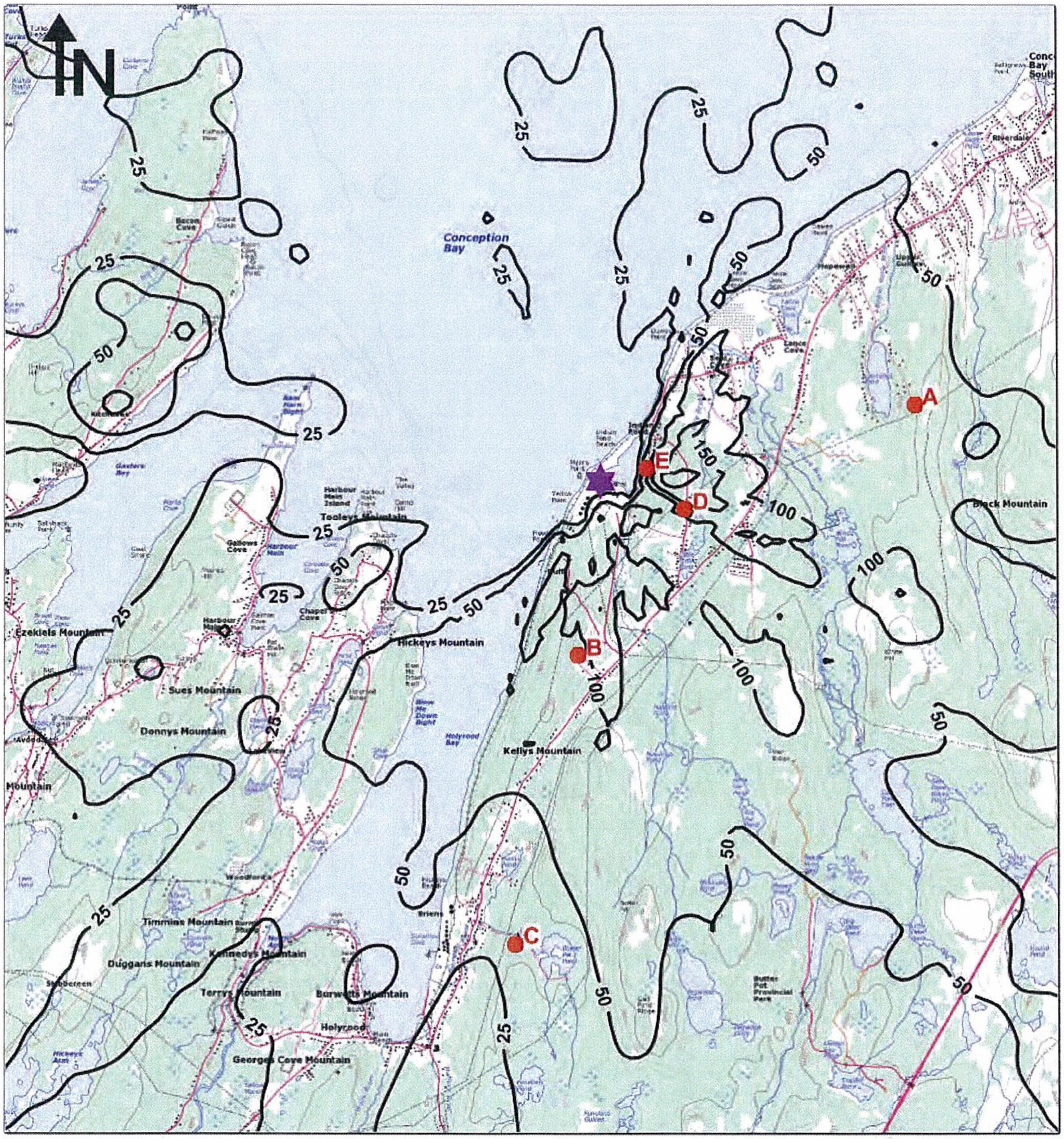
Figure 11 Maximum Annual Daily Predicted Concentration (µg/m³) of SO_2 in Ambient Air for the HTGS 2004 Production Scenario and the Combustion Turbine



Monitoring Sites
A: Lawrence Pond
B: Green Acres
C: Butter Pot
D: Indian Pond
E: Indian Pond Drive

AAQS: 300 µg/m³

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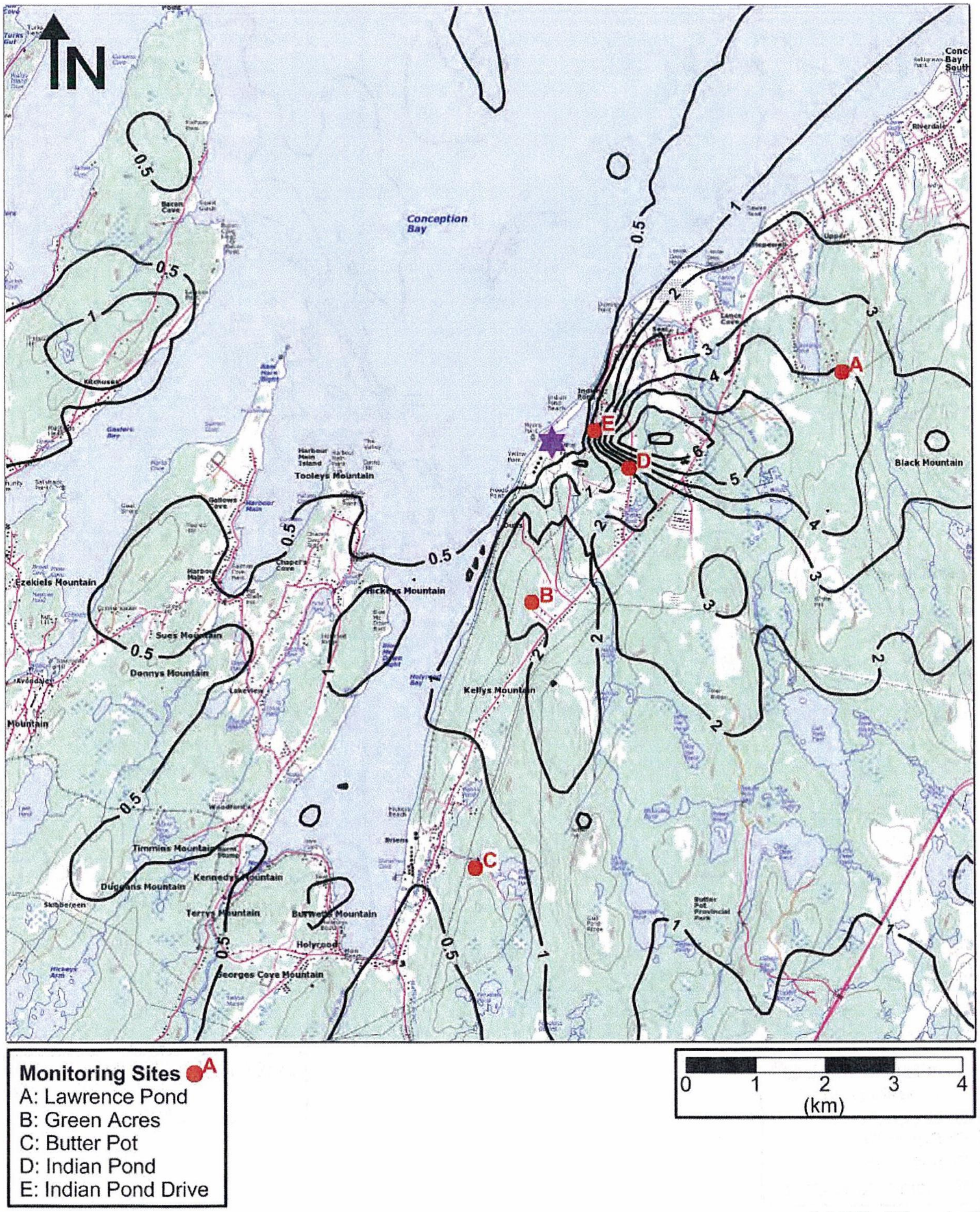
Figure 12 Maximum Annual Average Predicted Concentration (µg/m³) of SO_2 in Ambient Air for the HTGS 2003 Production Scenario and the Combustion Turbine



AAQS: 60 µg/m³

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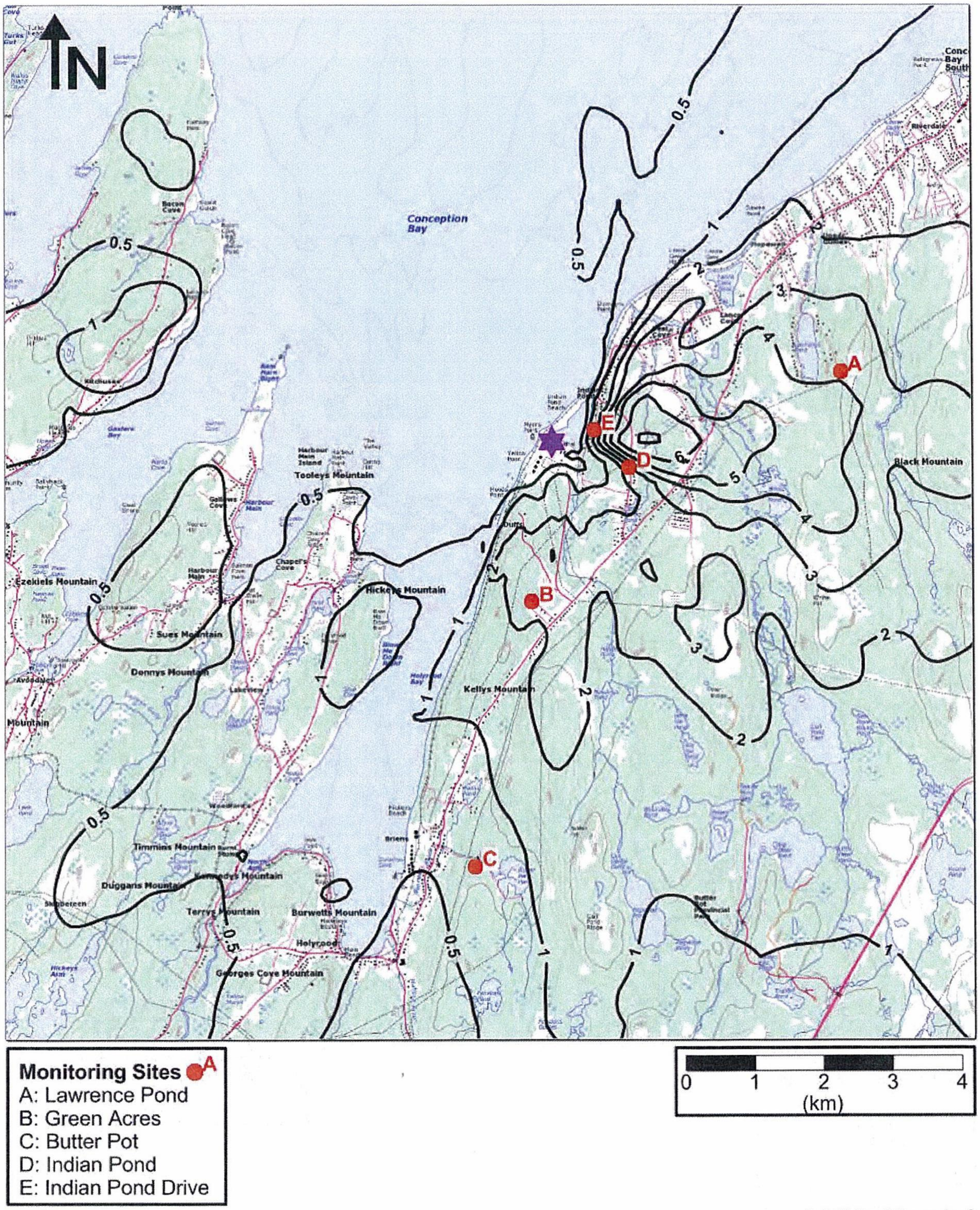
Figure 13 Maximum Annual Average Predicted Concentration (µg/m³) of SO_2 in Ambient Air for the HTGS 2004 Production Scenario and the Combustion Turbine



AAQS: 60 µg/m³

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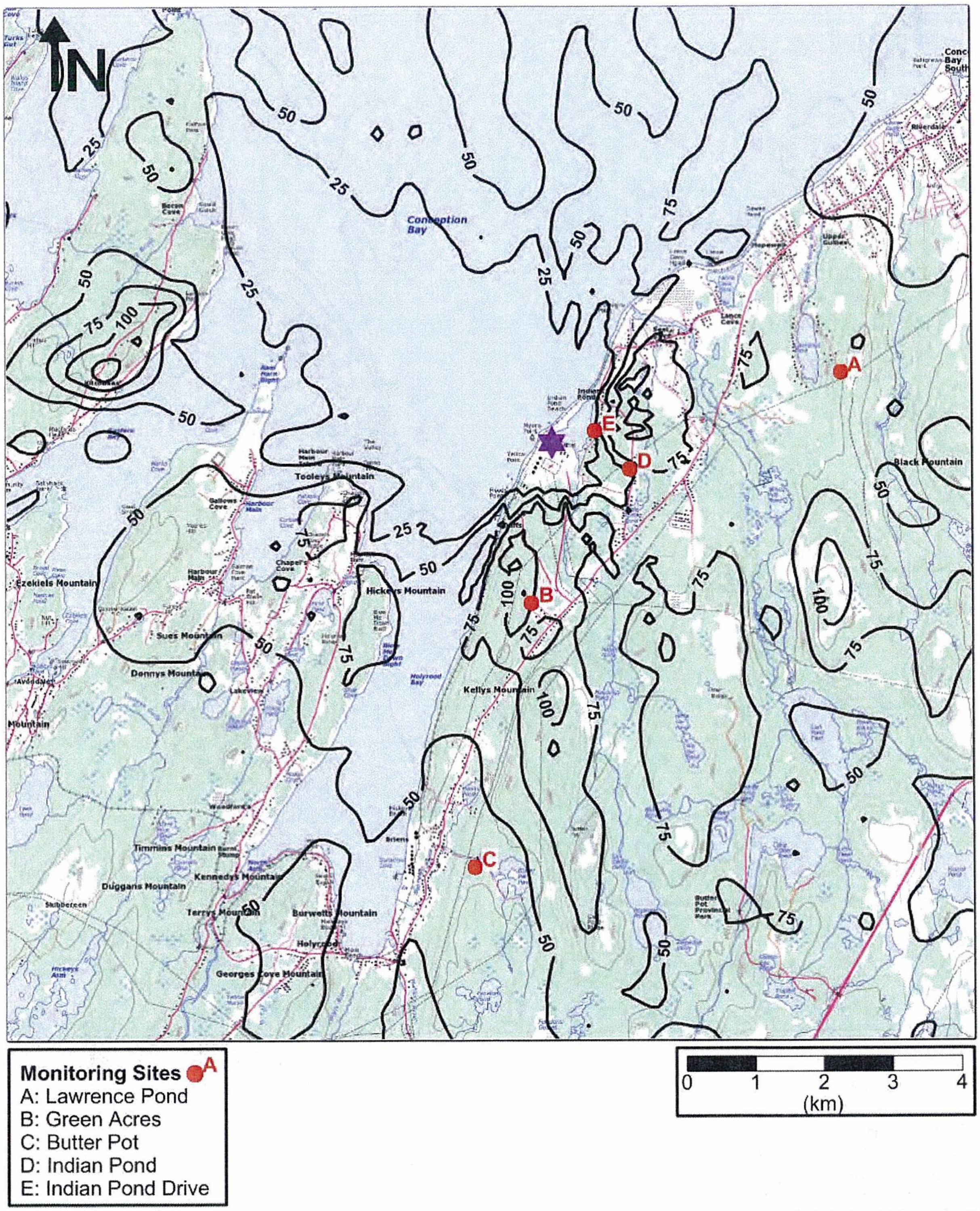
Figure 14 Maximum Annual Hourly Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the HTGS 2003 Production Scenario only



AAQS: 400 µg/m³

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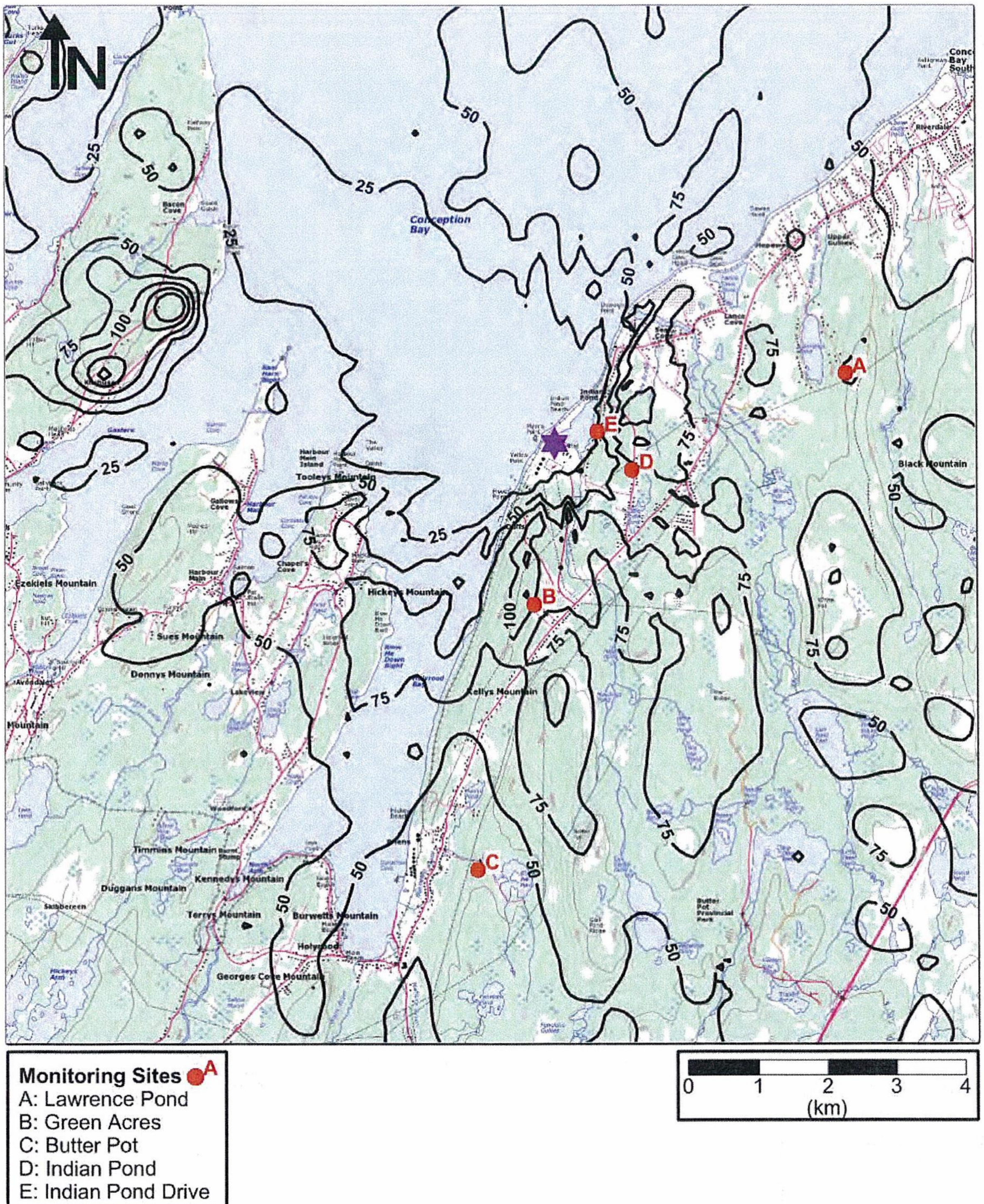
Figure 15 Maximum Annual Hourly Predicted Concentration (μg/m³) of NO_2 in Ambient Air for the HTGS 2004 Production Scenario only



AAQS: 400 μg/m³

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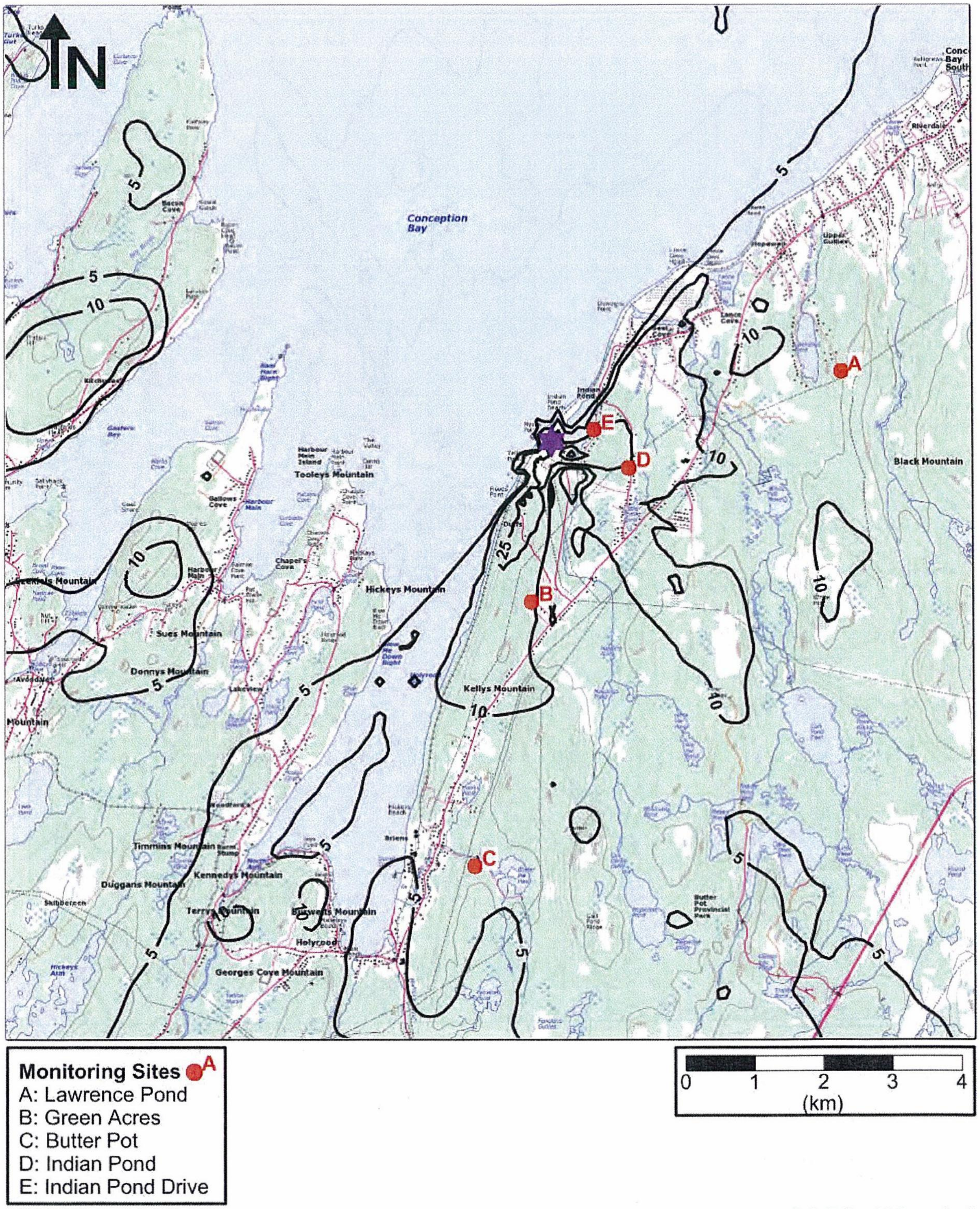
Figure 16 Maximum Annual Hourly Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the Combustion Turbine only



AAQS: 400 µg/m³

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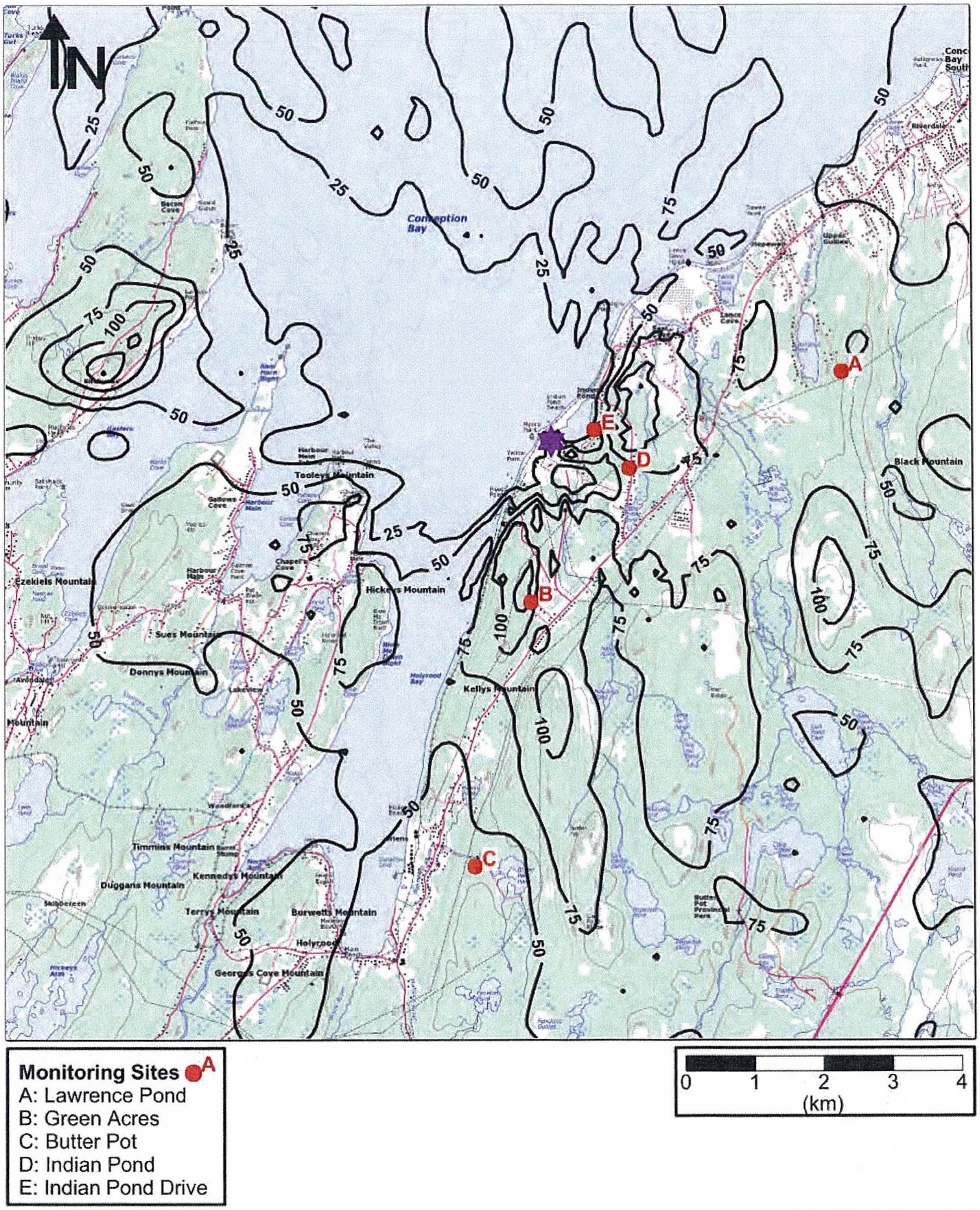
Figure 17 Maximum Annual Hourly Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the HTGS 2003 Production Scenario and the Combustion Turbine



AAQS: 400 µg/m³

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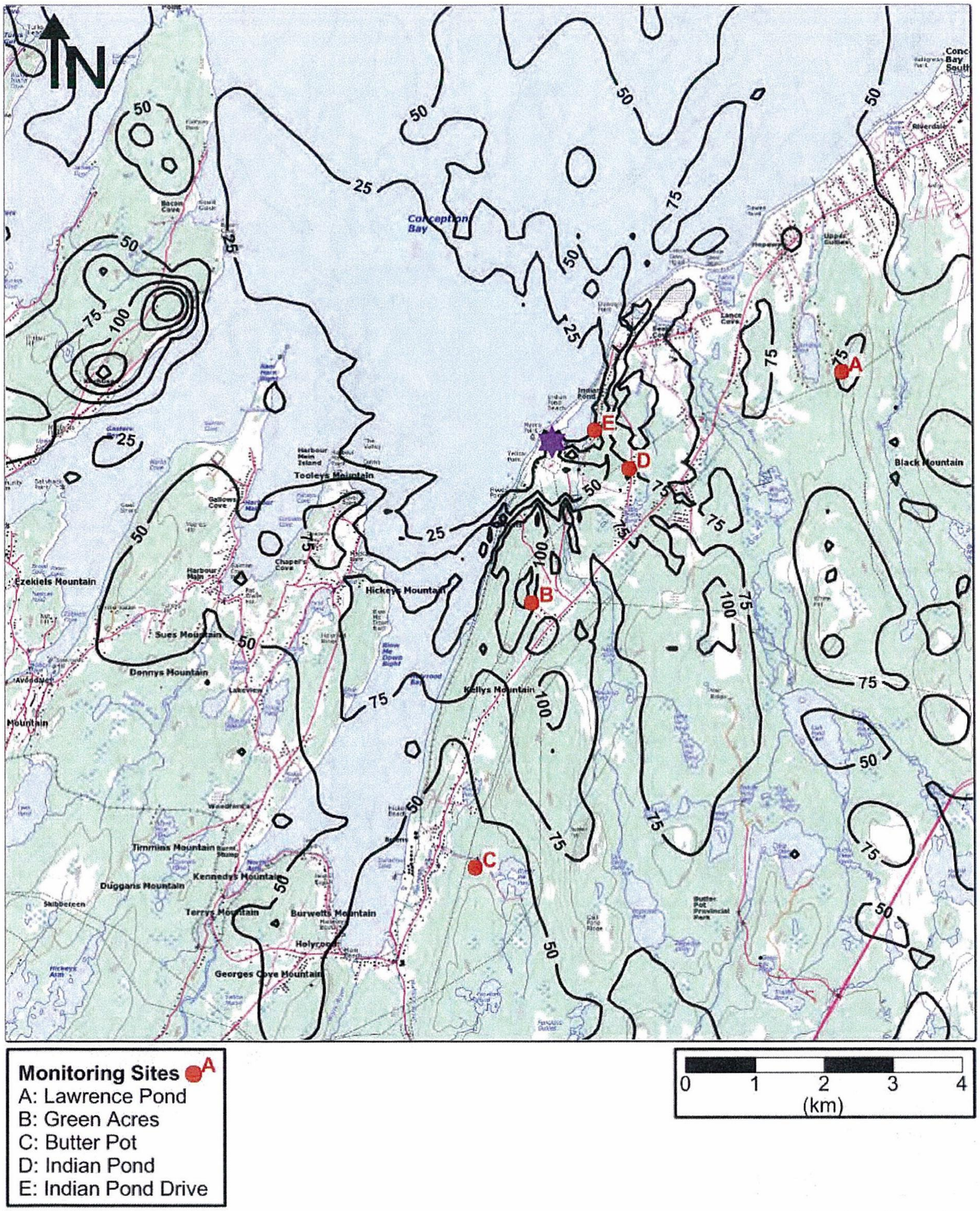
Figure 18 Maximum Annual Hourly Predicted Concentration (µg/m³) of NO_2 in Ambient Air for the HTGS 2004 Production Scenario and the Combustion Turbine



AAQS: 400 µg/m³

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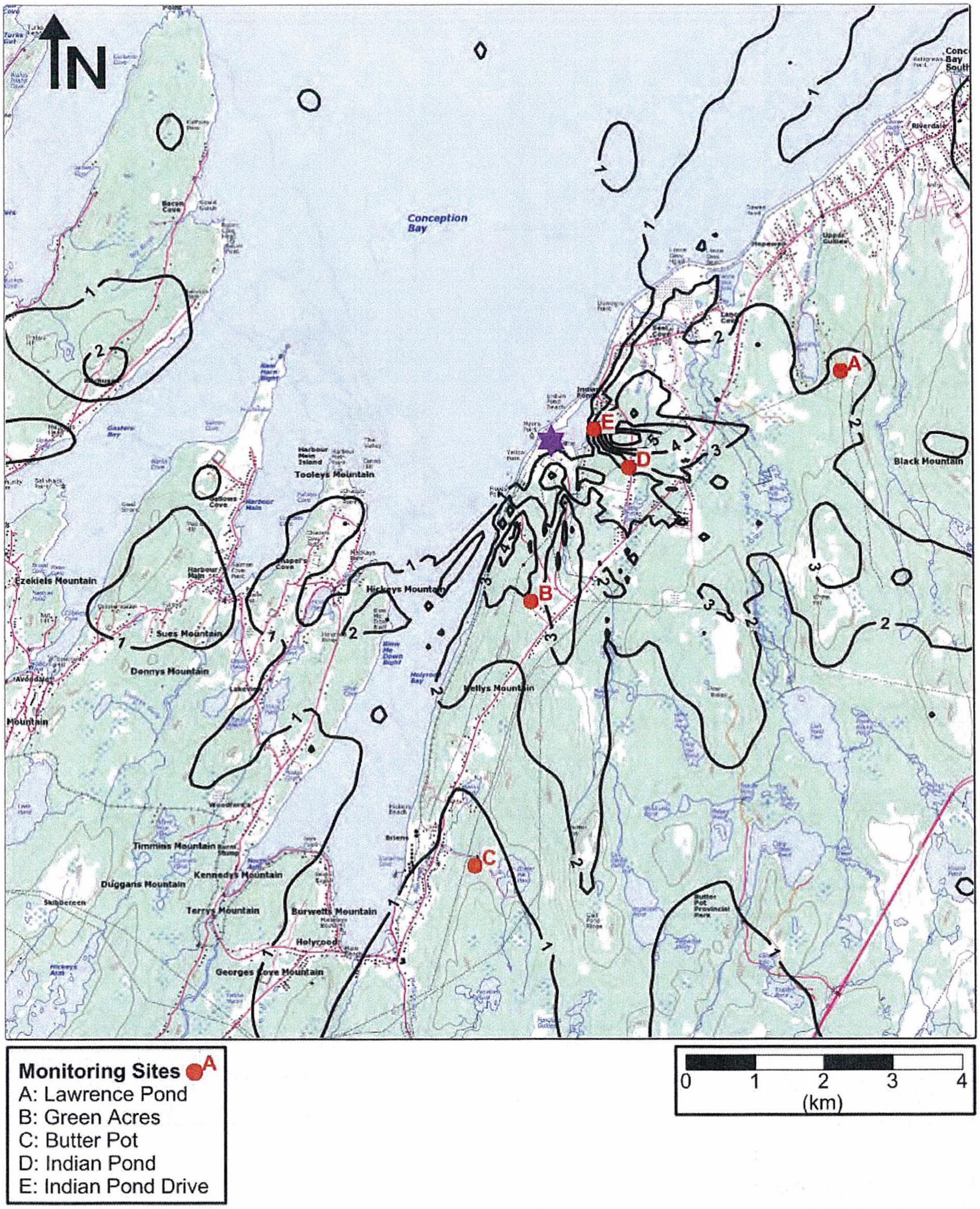
Figure 19 Maximum Annual Daily Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the HTGS 2003 Production Scenario only



AAQS: 30 µg/m³

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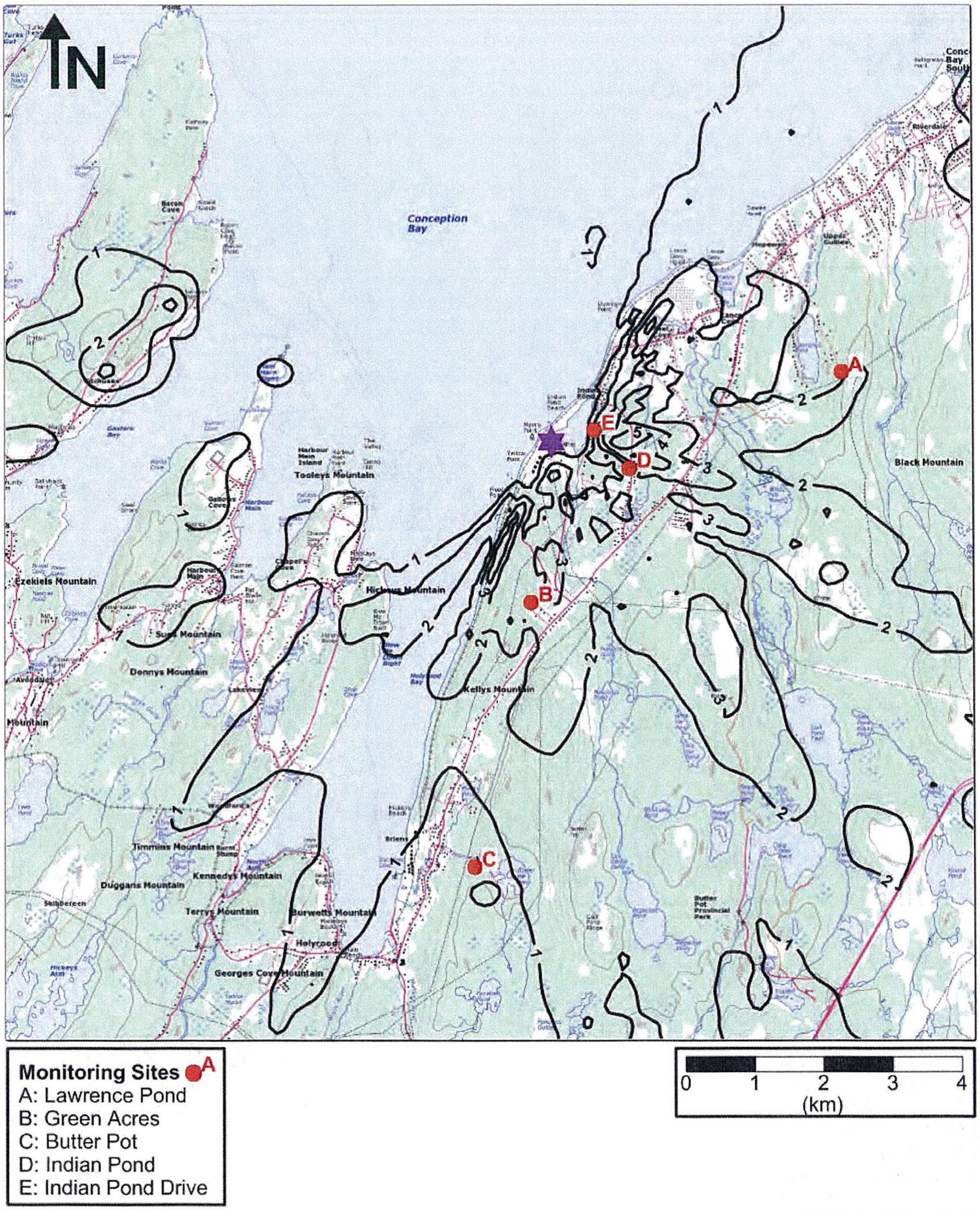
Figure 20 Maximum Annual Daily Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the HTGS 2004 Production Scenario only



AAQS: 30 µg/m³

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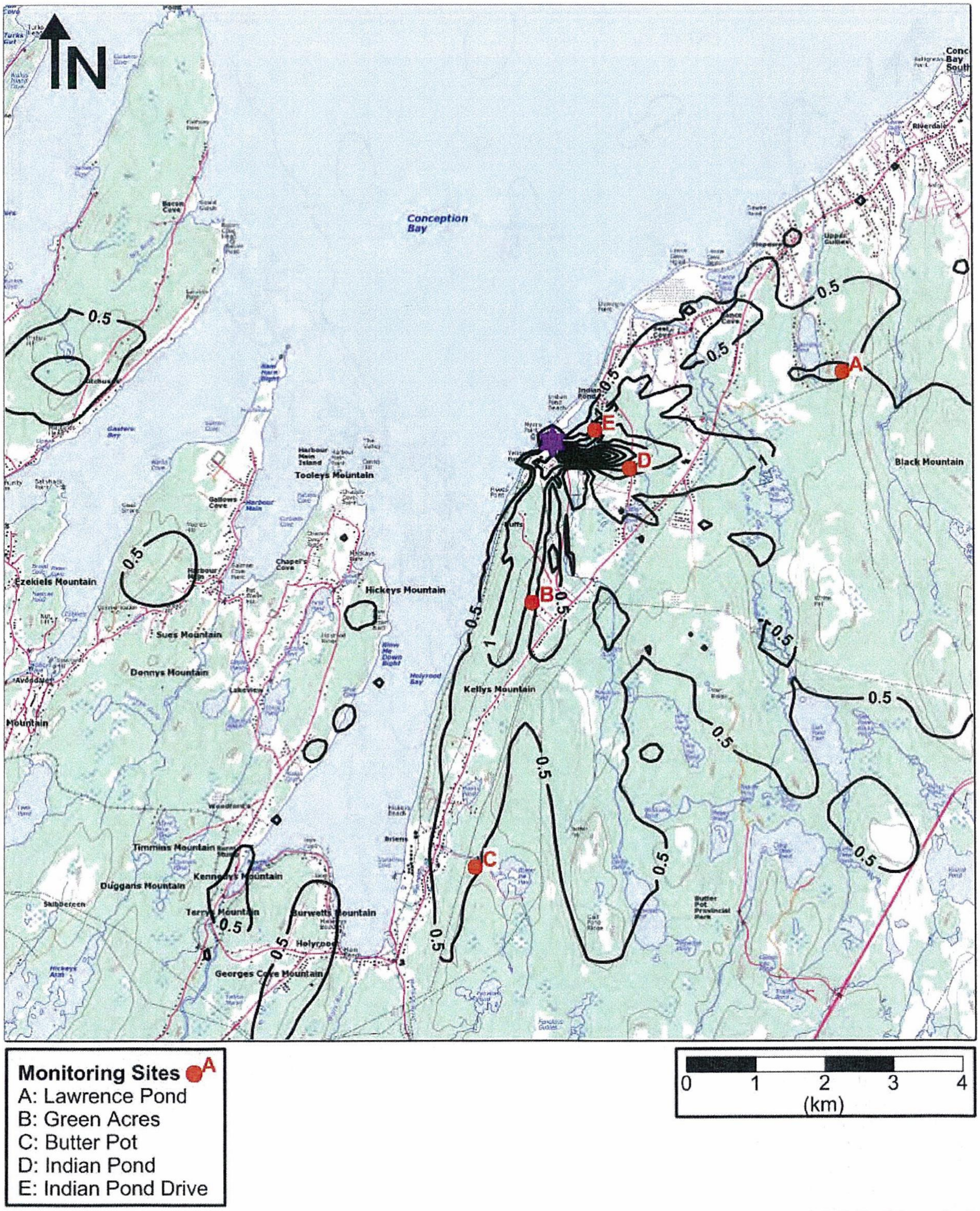
Figure 21 Maximum Annual Daily Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the Combustion Turbine only



AAQS: 30 µg/m³

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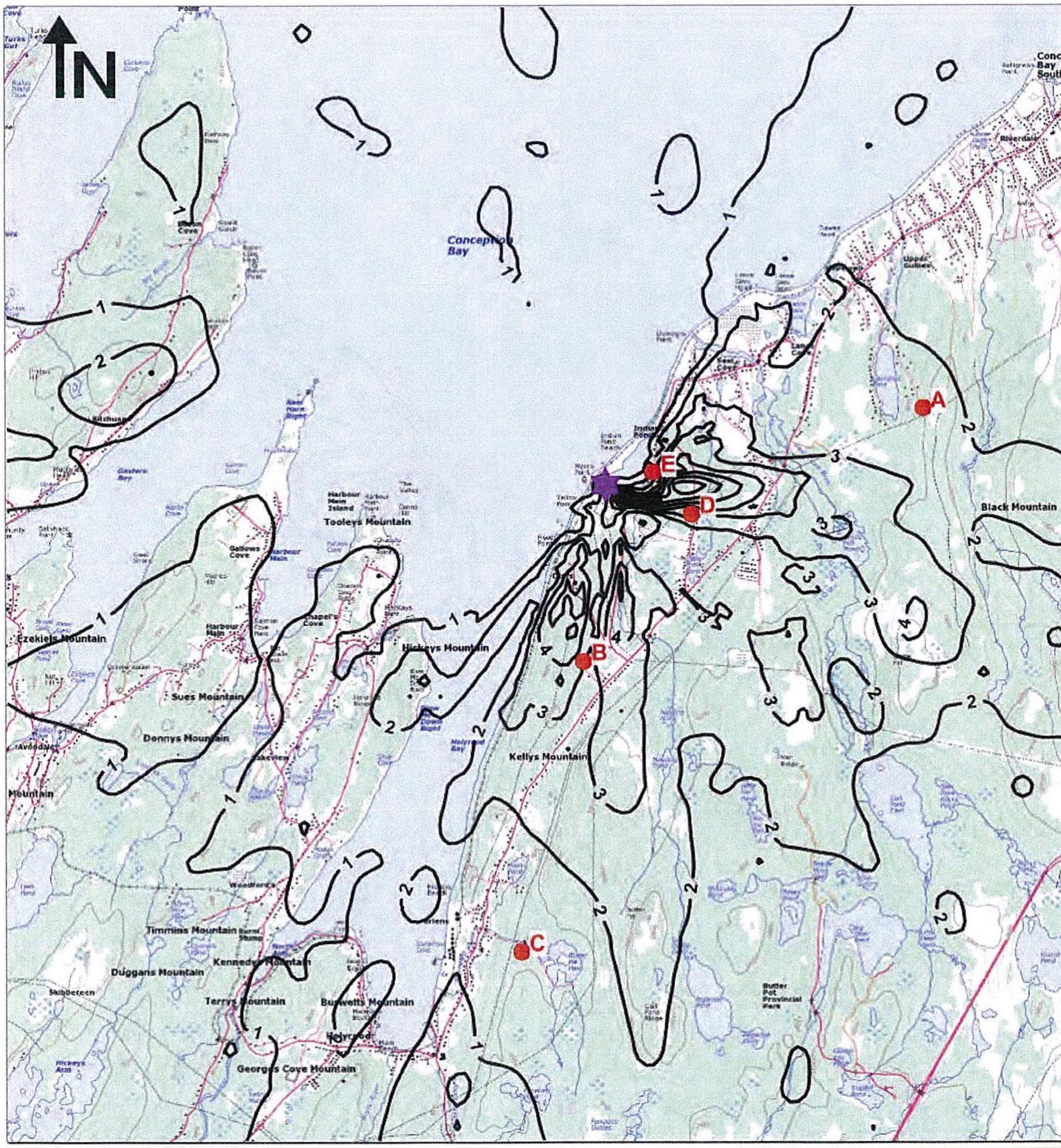
Figure 22 Maximum Annual Daily Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the HTGS 2003 Production Scenario and the Combustion Turbine

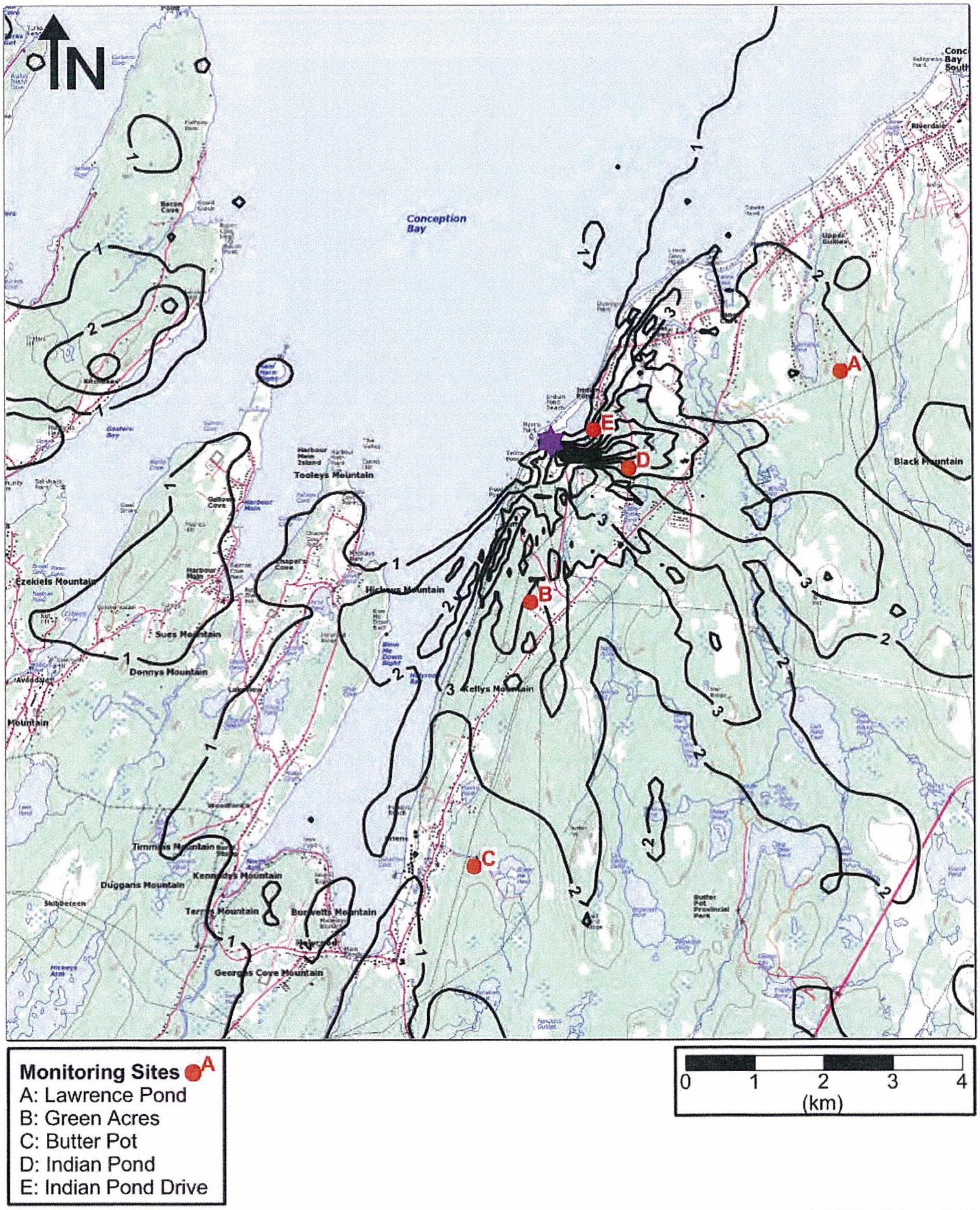


Monitoring Sites A
A: Lawrence Pond
B: Green Acres
C: Butter Pot
D: Indian Pond
E: Indian Pond Drive

0 1 2 3 4
(km)

AAQS: 30 µg/m³

Figure 23 Maximum Annual Daily Predicted Concentration (µg/m³) of $PM_{2.5}$ in Ambient Air for the HTGS 2004 Production Scenario and the Combustion Turbine



AAQS: 30 µg/m³

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5 CONCLUSIONS

The CALPUFF modelling system was used to estimate ground level concentrations of SO_2, NO_2, CO, PM_t, PM_{10} and $PM_{2.5}$ in ambient air in the Holyrood region resulting from the operation of the Hoylrood Thermal Generation Station (HTGS) with the addition of a nominal 123 MW (ISO rating) light fuel oil fired combustion turbine (CT) production unit.

Based on the HTGS highest production seasons (2003 and 2004) and expected emissions from the combustion turbine unit during constant operation at full load and over four years of meteorological data, modelling results show that the current HTGS will remain in compliance with the provincial Ambient Air Quality Standards (AAQS) with the operation of the CT unit.

For most contaminants, the addition of the CT unit would not significantly increase the maximum ground level concentrations in ambient air. The maximum impacts from the CT would be for $PM_{2.5}$ for a limited area extending a few hundred metres east from the HTGS site, but concentrations would still be well below the AAQS.

6 REFERENCES

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DOEC, 2012b. *Determination of Compliance with the Ambient Air Quality Standards.* GD-PPD-009.4, Newfoundland & Labrador Department of Environment & Conservation.

EarthTech, 2000a, *A User's Guide for the CALMET Meteorological Model*, EarthTech, January 2000.

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APPENDIX A

Comparison of MM5 Data with Meteorological Observations

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Appendix A

Comparison of MM5 Data with Meteorological Observations

This appendix presents a comparison of recorded/observed meteorological conditions at the Green Acres meteorological station with the MM5 generated data.

Figure A-1 shows the recorded (Green Acres) and the MM5 monthly average temperatures and precipitation for the 2009 to 2012 period. For temperature, the agreement between the recorded data and the MM5 data is nearly perfect. For precipitation, there is also good agreement (annual average of 1,172 mm for the Green Acres station versus 1,080 mm for the MM5 generated data) with some differences for a few of the months. For precipitation, heavy short-term events such as thunderstorms are very difficult to model in time and space. For modelling purposes, since precipitation removes contaminants from the plume, a slight underestimation in precipitation would lead to slightly more conservative modelling results.

Figure A-2 shows the 5-year wind roses based on the data recorded at the Green Acres station and the St. John's airport (25 km east of the HTGS) and for the MM5 data for the St. John's airport and the HTGS plant site. For both metrological stations and the MM5 generated data, prevailing winds shift from the west in St. John's to the southwest along the eastern coast of Conception Bay in the Holyrood area. Recorded wind data at the Green Acres station have a much lower average velocity than at the St. John's station or the MM5 generated data for both sites. This is most likely related to the location of the Green Acres station, which is in a forested area, while the airport and HTGS sites are in wide open areas allowing surface winds to reach much higher velocities.

The assessment of the ability of the MM5 to reproduce local climate conditions was judged conclusive by SNC-Lavalin and the DOEC resulting in the decision to disregard local observations in the CALMET analysis. Even though recorded data are preferable, CALMET's requirements (multi-surface stations, upper air observations and overwater meteorology) are very difficult to fulfill relying on recorded/observational data only. Also, combining observations with modelled meteorological fields can lead to unrealistic conditions, given that for a few hours per year, observations or CALMET sub-model and the MM5 generated data can be in disagreement. Consequently, since observations are limited, it is preferable to use complete and scientifically sound MM5 generated data only, especially since the MM5 data are in agreement with observations in the region.

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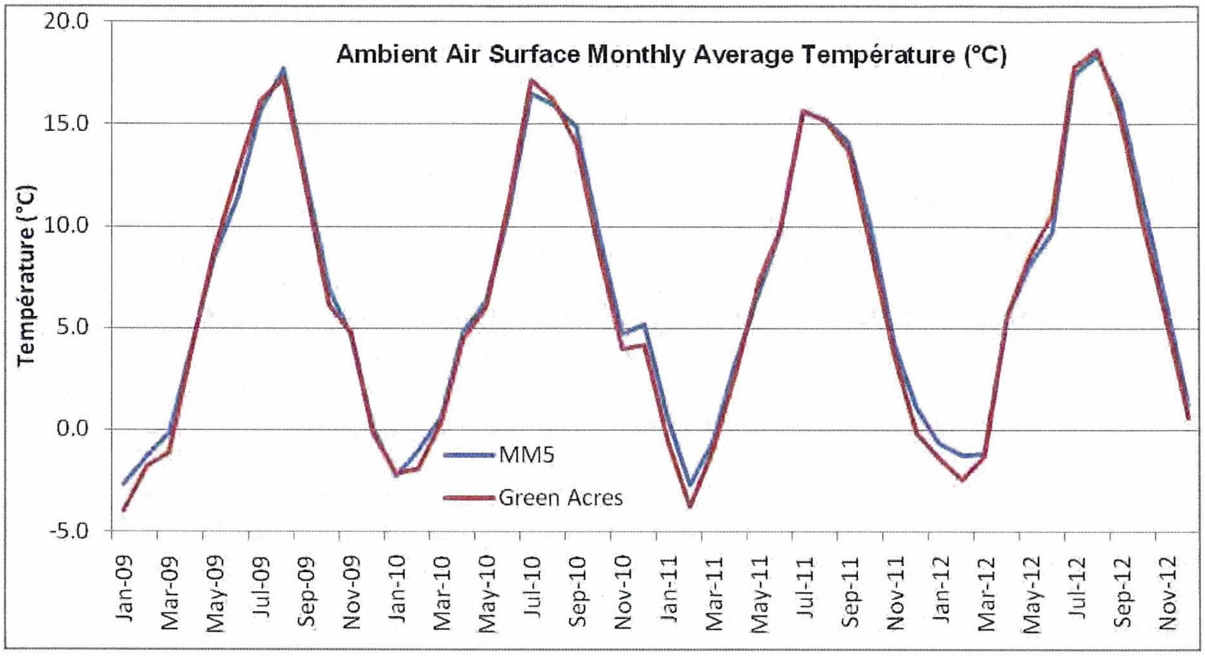
Figure A-1 Comparison of Monthly Temperature and Precipitation at the Green Acres Meteorological Station and at the HTGS MM5 Grid Point



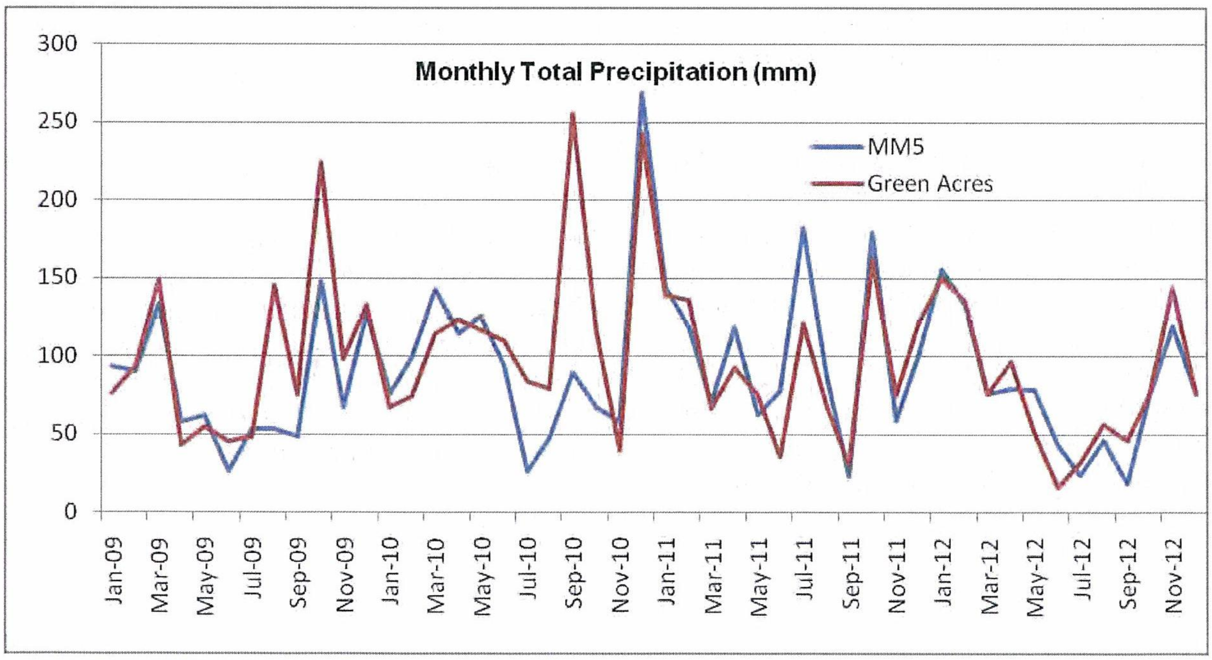


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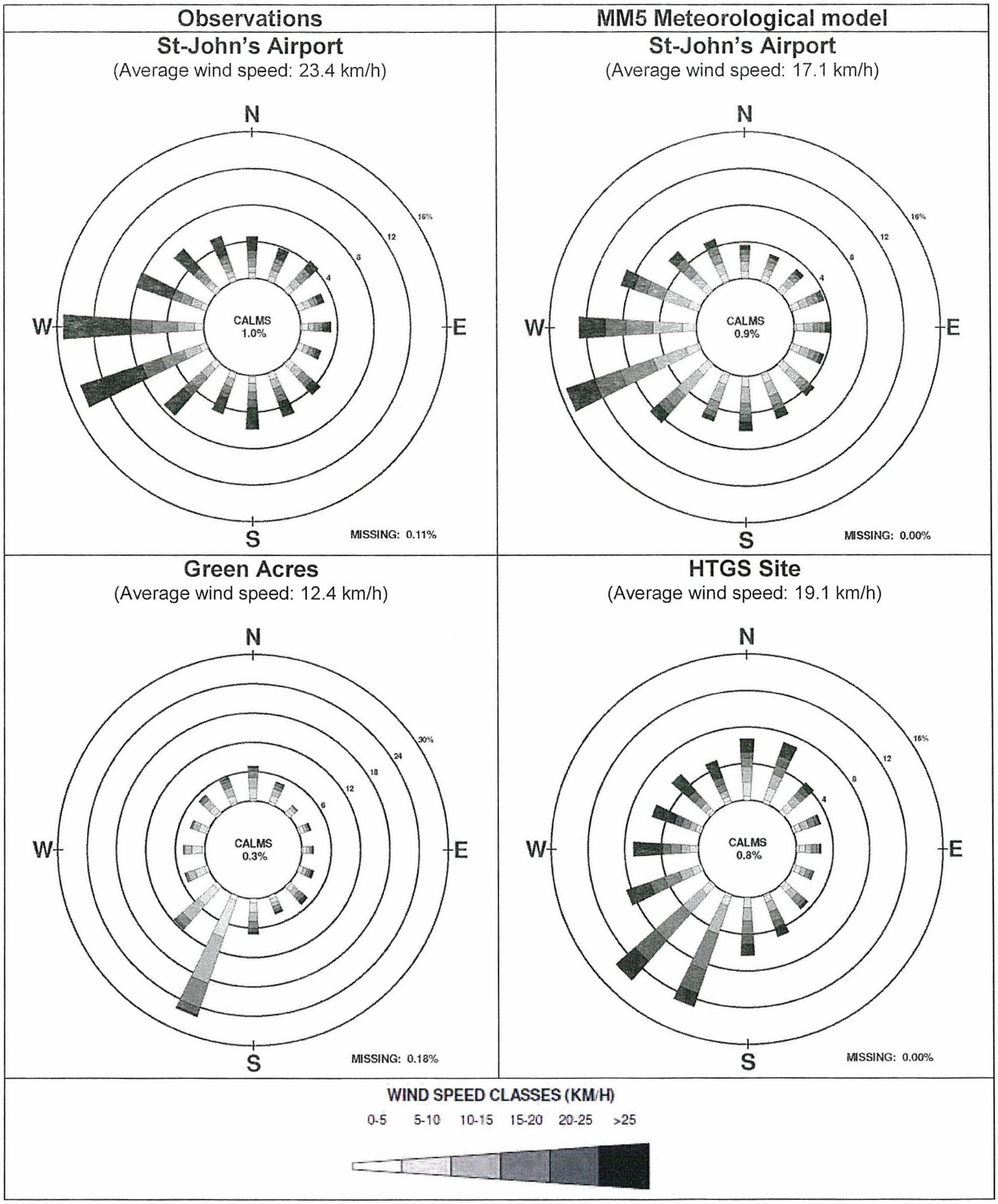
Figure A-2 Comparison on Wind Roses at St. John's Airport and Green Acres Meteorological Stations with Corresponding MM5 Grid Points (2009-2012)



APPENDIX B

HTGS Plant Site Wind Roses from MM5 Meteorological Model

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Figure B-1 Annual Wind Roses at the HTGS Site from MM5 Data (2009-2012)

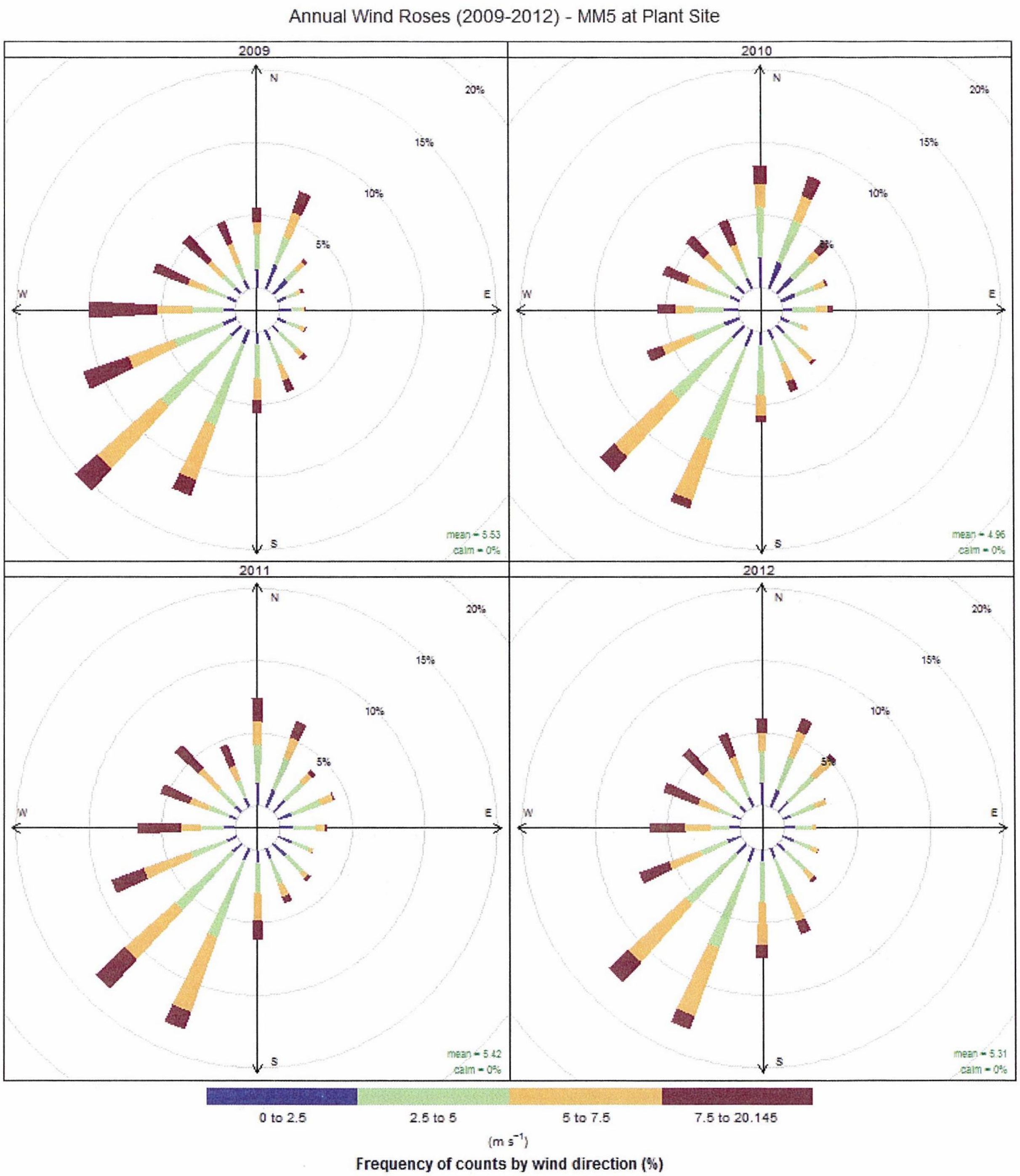

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Figure B-2 Seasonal Wind Roses at the HTGS Site from MM5 Data (2009-2012)

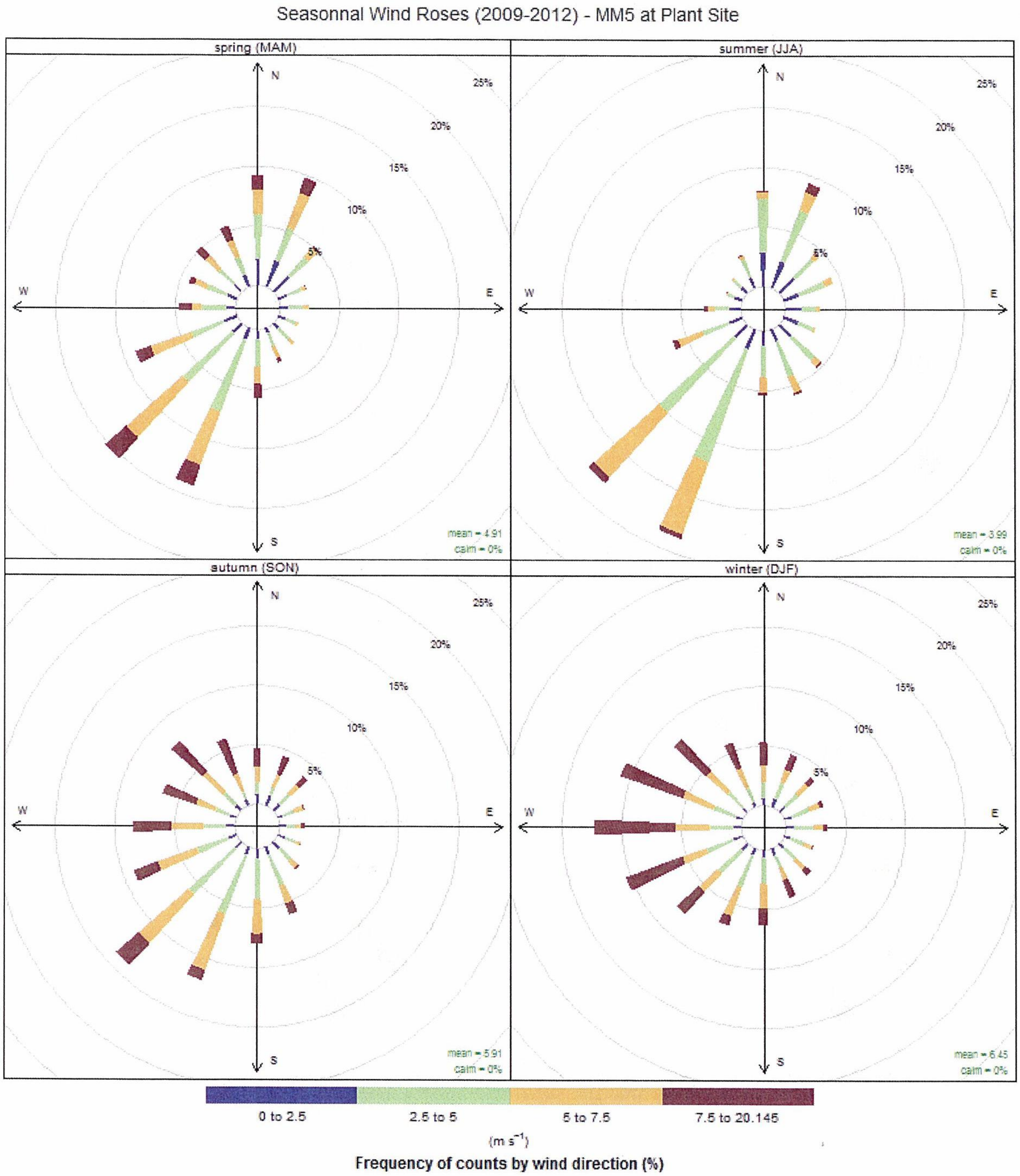

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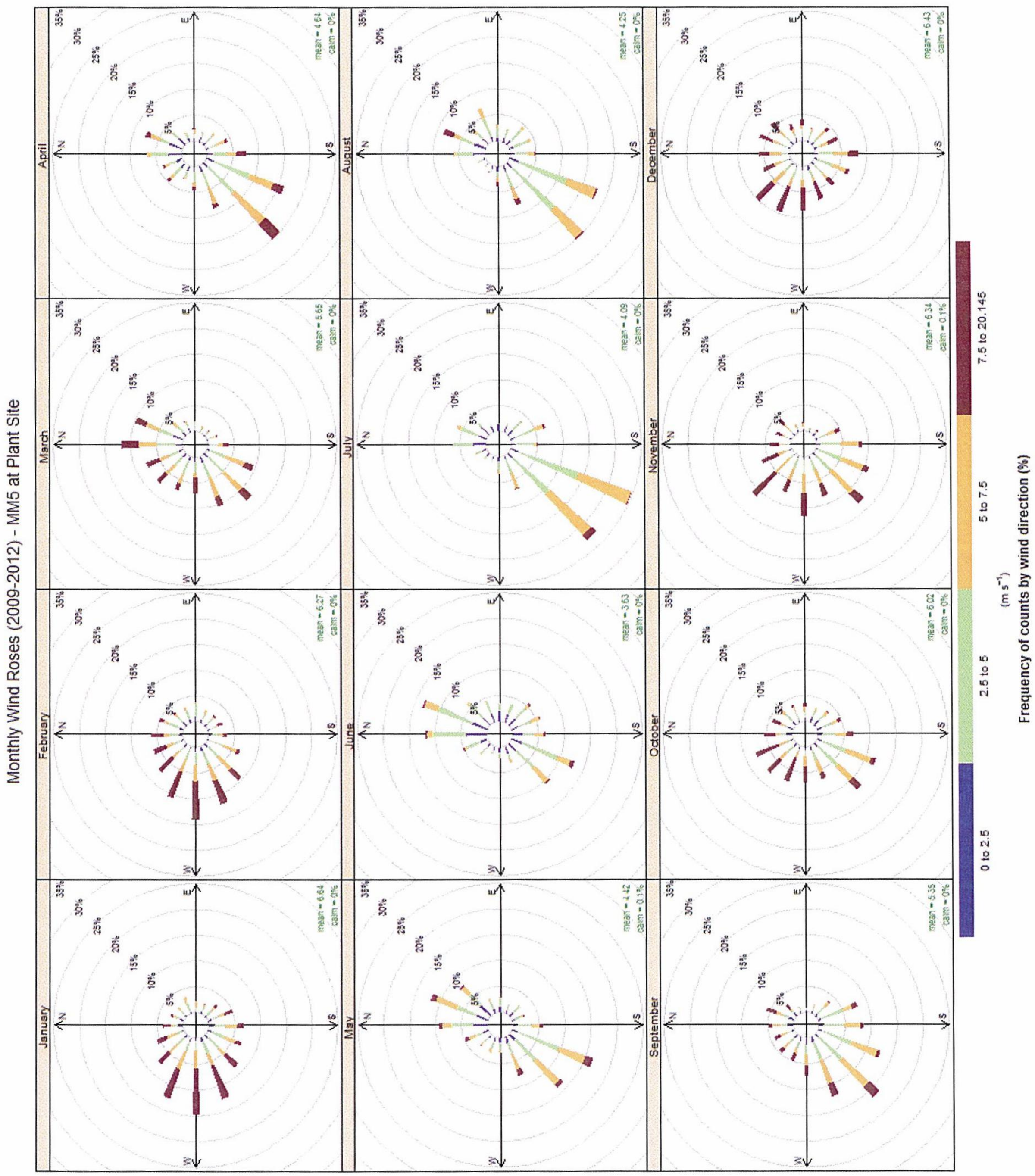
Figure B-3 Monthly Wind Roses at the HTGS Site from MM5 Data (2009-2012)



APPENDIX C

Maximum Predicted Concentrations per Year, Source Group and HTGS Production Scenario

Table C-1 Summary of CALPUFF Maximum Predicted Concentrations over all Receptors for the HTGS

HTGS 2003 Production Scenario										
Pollutant	Period	2009		2010		2011		2012		AAQS
		Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	
SO_2	1 h	513	57%	536	60%	468	52%	464	52%	900
	3h	461	77%	364	61%	352	59%	326	54%	600
	24 h	296	99%	176	59%	150	50%	157	52%	300
	Annual	7.0	12%	3.0	5.1%	4.3	7.1%	3.8	6.4%	60
NO_2	1h	115	29%	145	36%	110	27%	112	28%	400
	24 h	70	35%	50	25%	49	24%	44	22%	200
	Annual	2.2	2.2%	1.1	1.1%	1	1.4%	1.1	1.1%	100
CO	1h	0.41	0.001%	0.43	0.001%	0.30	0.0009%	0.35	0.001%	35,000
	8 h	0.27	0.002%	0.19	0.001%	0.19	0.0013%	0.18	0.001%	15,000
PM_t	1 h	22		23		20		20		n/a
	24 h	12	10%	7	6.1%	6	5.3%	6.6	5.5%	120
	Annual	0.29	0.48%	0.13	0.21%	0.18	0.30%	0.16	0.27%	60
PM_{10}	1h	16		18		15		15		n/a
	24 h	9.2	18%	6	11%	5	10%	5.0	10%	50
	Annual	0.22		0.10		0.14		0.12		n/a
$PM_{2.5}$	1 h	13		15		12		13		n/a
	24 h	7.5	30%	5	18%	4	16%	4.1	16%	25
	Annual	0.18		0.085		0.11		0.10		n/a
HTGS 2004 Production Scenario										
Pollutant	Period	2009		2010		2011		2012		AAQS
		Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	Conc. (μgm³)	% of AAQS	
SO_2	1 h	477	53%	663	74%	409	45%	586	65%	900
	3h	413	69%	307	51%	320	53%	318	53%	600
	24 h	234	78%	159	53%	167	56%	170	57%	300
	Annual	7.0	12%	3.2	5.3%	4.9	8.2%	4	6.8%	60
NO_2	1h	116	29%	220	55%	115	29%	112	28%	400
	24 h	62	31%	48	24%	48	24%	45	22%	200
	Annual	2.2	2.2%	1.1	1.1%	1.6	1.6%	1.2	1.2%	100
CO	1h	0.35	0.001%	0.40	0.001%	0.31	0.001%	0.46	0.001%	35,000
	8 h	0.23	0.002%	0.16	0.001%	0.19	0.001%	0.19	0.001%	15,000
PM_t	1 h	21		26		18		27		n/a
	24 h	10	8%	7.0	5.9%	7.2	6.0%	7.8	6.5%	120
	Annual	0.30	0.51%	0.14	0.24%	0.22	0.36%	0.17	0.29%	60
PM_{10}	1h	16		22		13		19		n/a
	24 h	7.2	14%	5.6	11%	5.5	11.0%	5.8	12%	50
	Annual	0.23		0.11		0.17		0.13		n/a
$PM_{2.5}$	1 h	13		19		11		16		n/a
	24 h	5.9	24%	4.7	19%	4.5	18%	4.8	19%	25
	Annual	0.19		0.09		0.14		0.11		n/a

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Table C-2 Summary of CALPUFF Maximum Predicted Concentrations over all Receptors for the Combustion Turbine

Combustion Turbine										
Pollutant	Period	2009		2010		2011		2012		AAQS
		Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	
SO_2	1 h	41	4.5%	33	3.6%	39	4.4%	36	4.0%	900
	3h	36	5.9%	22	3.7%	32	5.3%	28	4.7%	600
	24 h	25	8.3%	11	3.7%	14	4.5%	11	3.8%	300
	Annual	0.51	0.85%	0.081	0.1%	0.25	0.42%	0.18	0%	60
NO_2	1h	94	23%	76	19.0%	89	22%	84	21%	400
	24 h	56	28%	25	13%	29	15%	26	13%	200
	Annual	1.2	1.2%	0.18	0.2%	0.57	0.57%	0.41	0.41%	100
CO	1h	17	0.048%	14	0.0%	16	0.047%	15	0.043%	35,000
	8 h	13	0.085%	8.0	0.1%	12	0.08%	9.0	0.06%	15,000
PM_t	1 h	27		21		26		24		n/a
	24 h	16	14%	7.3	6.1%	9.0	7.5%	7.6	6.3%	120
	Annual	0.34	0.56%	0.053	0.089%	0.16	0.27%	0.12	0.20%	60
PM_{10}	1h	27		21		26		24		n/a
	24 h	16	33%	7.3	15%	9.0	18%	7.6	15%	50
	Annual	0.34		0.053		0.16		0.12		n/a
$PM_{2.5}$	1 h	27		21		26		24		n/a
	24 h	16	65%	7.3	29%	9.0	36%	7.6	30%	25
	Annual	0.34		0.053		0.16		0.12		n/a

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Table C-3 Summary of CALPUFF Maximum Predicted Concentrations over all Receptors for the HTGS and Combustion Turbine

HTGS 2003 Production Scenario + Combustion Turbine										
Pollutant	Period	2009		2010		2011		2012		AAQS
		Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	
SO_2	1 h	514	57%	550	61%	472	52%	464	52%	900
	3h	463	77%	365	61%	355	59%	328	55%	600
	24 h	297	99%	177	59%	151	50%	159	53%	300
	Annual	7.1	12%	3.1	5.1%	4.3	7.2%	3.8	6.4%	60
NO_2	1h	124	31%	153	38%	117	29%	116	29%	400
	24 h	80	40%	55	28%	51	25%	48	24%	200
	Annual	2.4	2.4%	1.1	1.1%	1.5	1.5%	1.2	1.2%	100
CO	1h	17	0.048%	14	0.039%	16	0.047%	15	0.043%	35,000
	8 h	13	0.085%	8.0	0.053%	12	0.077%	9.0	0.060%	15,000
PM_t	1 h	27		23		26		28		n/a
	24 h	16	13.6%	8.4	7.0%	9.0	7.5%	7.7	6.4%	120
	Annual	0.35	0.58%	0.14	0.24%	0.20	0.34%	0.18	0.29%	60
PM_{10}	1h	27		21		26		24		n/a
	24 h	16	33%	7.3	15%	9.0	18%	7.6	15%	50
	Annual	0.34		0.12		0.16		0.14		n/a
$PM_{2.5}$	1 h	27		21		26		24		n/a
	24 h	16	65%	7.3	29%	9.0	36%	7.6	30%	25
	Annual	0.34		0.10		0.16		0.13		n/a

HTGS 2004 Production Scenario + Combustion Turbine										
Pollutant	Period	2009		2010		2011		2012		AAQS
		Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	Conc. (µgm³)	% of AAQS	
SO_2	1 h	479	53.2%	663	73.6%	410	45.6%	589	65.4%	900
	3h	413	68.9%	309	51.5%	320	53.4%	319	53.1%	600
	24 h	234	78.1%	161	53.5%	167	55.6%	170	56.6%	300
	Annual	7.1	11.8%	3.2	5.4%	5.0	8.3%	4.1	6.8%	60
NO_2	1h	123	30.7%	220	55.0%	131	32.8%	124	31.0%	400
	24 h	68	33.8%	52	25.9%	48	24.2%	48	24.1%	200
	Annual	2.4	2.4%	1.1	1.1%	1.7	1.7%	1.3	1.3%	100
CO	1h	17	0.0%	14	0.0%	16	0.0%	15	0.0%	35,000
	8 h	13	0.1%	8.0	0.1%	12	0.1%	9.0	0.1%	15,000
PM_t	1 h	27		26		26		29		n/a
	24 h	16	13.6%	8.6	7.2%	9.0	7.5%	8.8	7.3%	120
	Annual	0.36	0.6%	0.16	0.3%	0.24	0.4%	0.19	0.3%	60
PM_{10}	1h	27		22		26		24		n/a
	24 h	16	32.7%	7.3	14.7%	9.0	18.0%	7.6	15.2%	50
	Annual	0.35		0.13		0.19		0.15		n/a
$PM_{2.5}$	1 h	27		21		26		24		n/a
	24 h	16	65.4%	7.3	29.4%	9.0	35.9%	7.6	30.3%	25
	Annual	0.34		0.11		0.16		0.13		n/a


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